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CHANNEL CATFISH CULTURE IN CALIFORNIA

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Central Valleys Fish Hatchery, Elk Grove, California

THE CHANNEL CATFISH (Ictalurus punctatus) has been introduced into California, like the many other nonnative game fish that are now widespread over the State. The channel catfish has become established in some southern California reservoirs, in the Colorado River, and in the Lower Sacramento River drainage system near the City of Sacramento. The channel catfish is such a desirable game fish that the California Department of Fish and Game felt that it should be introduced into more of the large warm-water reservoirs. An attempt to raise the channel catfish in California was started at the Central Valleys Fish Hatchery, the only state-operated warm-water hatchery on the Pacific coast.

As the channel catfish has been successfully raised in several other States, the technique of its culture was known to us. However, each installation is different, so that it was necessary to test various methods until the technique most suitable for each installation could be evolved. The purpose of this report is to describe the methods used at the Central Valleys Fish Hatchery and the results of our work.

The program in California started when we began to trap wild fish for brood stock in the summer of 1957. The ordinary hoop nets commonly used in commercial fishing for catfish were set in the Sacramento River near the Fremont weir and in the south side of the Sutter Bypass borrow pits. Enough brood stock were obtained to start the hatchery program in 1958.

Eight standard redwood trout-hatchery troughs were used at the beginning. These troughs measured 17 feet 10 inches long, 1 foot 3.5 inches wide, and 6 inches deep, and held about 86 gallons of water. The channel catfish eggs were removed from the spawning containers and brought to the hatchery, where each spawn was placed in an individual hatching basket. There was no successful hatching of the eggs until a paddle mechanism that worked over them was installed and put into operation. With the paddle arrangement and the malachite-green flush treatment, eggs were successfully hatched and 130,000 fingerlings were produced and planted in 1958.

In 1959, the hatchery was moved to a new location and enlarged to 20 troughs. Four troughs were converted into hatching troughs in which the catfish eggs could be handled with the paddle mechanism. As each trough held 4 egg baskets, 16 spawns could be handled at a time. The paddles were motivated by an electric motor with gear reduction which turned the shaft activating the paddles at 36 revolutions per minute. In 1959, 620,000 channel catfish ranging in size from 100 to 25 per ounce were planted.

In 1960, 973,668 channel catfish fingerlings were produced. Of these, 635,678 fingerlings were planted. These plantings took care of ali the allotments for 1960. The remaining fingerlings were placed in four hatchery ponds, of which three were 0.32 surface acre each and one was 1.44 surface acre in size. The catfish were placed in the ponds to determine whether they could be raised to a larger size for planting. All the catfish in two of these ponds (including the 1.44-acre pond) died

of an Ichthyophthirius infestation. On October 18, the remaining two ponds were drained and 57,410 channel catfish fingerlings in good condition were removed and planted in the Owens River. The catfish from one of these ponds were 30 per ounce in size, and those from the other pond were 13 per ounce. This was a return of 63 percent from the two ponds.

The Channel Catfish Hatchery

The hatchery where the eggs and fry were held contained 20 standard redwood trout-hatchery troughs. These troughs were also 17 feet 10 inches long, 1 foot 3.5 inches wide, and 6 inches deep, with a volume of about 86 gallons. A flow of 10 to 12 gallons per minute passed through each trough. In addition to the troughs, three redwood tanks were set up to hold fingerlings. These tanks were 15 feet 3 inches long, 2 feet 10 inches wide, and 1 foot 9 inches deep, and contained about 500 gallons of water when full. A flow of 12 gallons per minute went through the tanks. Two concrete daphnia-culture tanks were also used to rear channel catfish fingerlings. These tanks were 50 feet long, 20 feet wide, and filled to a depth of about 6 inches. They contained about 3,700 gallons of water, and five spray-type nozzles in each tank discharged about 25 gallons per minute into the tanks. The redwood tanks and concrete daphnia tanks had shade covers provided. The troughs were in a roofed shed but also had trough covers to exclude as much light as possible. The redwood tanks and troughs were painted with black asphaltum paint to help keep them dark. We have found that the channel catfish fingerlings do best when protected from bright light.

The Water Supply

The hatchery ponds were supplied with water from a deep well. A 75-horsepower electric pump delivered about 1,400 gallons per minute. The water from the well contained no oxygen, and its temperature was a constant 68° F. In order to have warmer water with a supply of oxygen, a 1.87-acre pond containing 7.2 acre-feet of water was used as a reservoir. A 3-horsepower 6-inch pump installed in the pond was run 24 hours a day while the channel catfish hatchery was in operation. A fine-screen enclosure was put around the sump to keep predatory insects from being pumped into the hatchery troughs and tanks. A commercial weed-killer was used, usually at the rate of 1 to 2 p.p.m., to keep plant life under control.

The Channel Catfish Brood Stock

The brood stock used at the hatchery were wild fish trapped in the Sacramento River and Sutter Bypass areas north of the City of Sacramento. Hoop nets of the type used by commercial catfish fishermen were used. Some of these trap-nets were made at the hatchery. The most successful type of trap, made of 1-inch-square mesh of 24-thread twine and treated with hot tar, was 16 feet in total length and had 7 hoops, the mouth or open end being 4 feet in diameter. Some traps made of 2-inch-square mesh were also used, but they would not catch any catfish. Trapping was carried on in 1957, 1958, and 1959. Sometimes traps that were set for weeks would catch very few catfish. Once in a while a trap would have 200 to 300 pounds of catch--white catfish as well as channel catfish. The brood stock were held in one 0.44-acre pond and two 0.32-acre ponds. They were fed about three times a week in the summer and once a week in the winter. They were given about 3 percent of their body weight at each feeding. Originally the food given was freshly ground frozen ocean fish and freshly ground frozen beef liver. The catfish did not care much for the ocean fish but always liked the beef liver. In 1960 we started giving the catfish some 5/32-inch trout pellets with about one feeding of liver a week. Up to this time the brood stock have appeared to be in excellent condition and the mortality has been negligible.

In 1958 some of the brood stock were treated with pituitary extract, but there were no noticeable changes. Subsequent results in these spawning ponds indicated

that treatment with pituitary extracts was not necessary at this installation. Spawning was very satisfactory when the brood stock were removed from the pens and turned loose in the ponds.

Spawning in 1960

Early in May the brood stock were sorted, weighed, and put into three ponds.

Pond 11 (0.44 surface acre) received 50 females averaging 9.1 pounds in weight and 45 males averaging 9.2 pounds. Two of the largest females weighed 15 pounds each; the largest male weighed 14 pounds.

Pond 10 (0.32 surface acre) received 50 females averaging 6.1 pounds in weight and 41 males averaging 6.7 pounds. The largest females weighed 7 pounds each; the largest males weighed 8 pounds each.

Pond 9 (0.32 surface acre) received 50 females averaging 5.2 pounds in weight and 41 males averaging 5.8 pounds. The largest female weighed 7 pounds, and the largest males 8 pounds each. Additional subadult fish were also held in this pond.

The use of pens with one pair of adults in each pen was tried at our hatchery but proved unsatisfactory. We now put 15 to 20 spawning devices in each pond. Seventeen of the spawning containers were made of terra-cotta pipe, 25 inches long and 14 inches in diameter, with one end boarded shut. Thirty-five containers were 10- and 15-gallon milk cans. All the spawning containers were painted inside and outside with black asphaltum paint. The spawning containers along the edge of the pond were placed with the opening facing into the pond. Five or six containers were also placed along the center of the pond. To make it easier to find the containers when checking for eggs, each container had a float marker. The containers were placed in water 3 to 5 feet deep. In 1959 some eggs were laid in muskrat holes, and in one very muddy pond several nests were made right on the bottom. The nests were checked every other day and sometimes oftener if men were available from other duties.

Each container was checked by a man who wore a face mask and put a gloved hand into the container to find out whether eggs had been laid. A glove was used to protect the hand in case the adult guarding the nest should bite. If eggs were found, they were carefully removed, placed in a bucket, and taken to the hatching troughs. Each spawn of eggs was weighed, and the total number of eggs in each spawn was calculated on the basis of 500 eggs per ounce. The smallest spawn taken totaled 7,500 eggs; the largest, 57,500 eggs. The brood stock seemed to prefer the milk cans for spawning. Of the 62 spawns taken, 43 were found in the cans and only 19 were found in the terra-cotta pipes.

Pond 11, containing the largest brood stock, produced 37 spawns for a total of 1,040,500 eggs. Pond 10, which had the medium-sized brood stock, produced 23 spawns totaling 525,000 eggs. Pond 9, containing the smallest brood stock, had only 2 spawns totaling 52,500 eggs. (See table.)

In 1959, the first spawn was taken on May 11 and the last on July 14. In 1960, when the spring was cooler, the first spawn was taken on June 3 and the last on July 5. There was spawning after this date, but no more eggs were taken because the hatchery facilities were overloaded.

Handling of Eggs, Fry, and Fingerlings

The water temperature during the operation of the hatchery ranged from 66° to 84° F., but most of the time it was between 74° and 80° F. When the eggs were brought to the hatchery, they were weighed to get a count and then placed in the hatching baskets. These were made of wire mesh, with spaces wide enough for the fry to drop through after the eggs hatched. The baskets were 16 inches long, 12 inches wide, and 6.5 inches deep, with 1-inch wooden cleats under each corner so that the fry could swim freely after dropping from the basket. Four baskets were put in each of the four hatching troughs, with screens separating each basket area. Sixteen paddles were fixed to the hatching troughs so that they worked back and forth over the eggs in each basket. The paddles

CHANNEL CATFISH SPAWNING RECORD, 1960

Pond 9				Pond 10				Pond 11			
No.	Date	Type[1/]	Number of eggs	No.	Date	Type	Number of eggs	No.	Date	Type	Number of eggs
	June				June				June		
1	3	can	25,000	1	9	can	25,000	1	3	can	25,000
2	9	can	27,500	2	13	keg	25,000	2	3	can	29,000
				3	13	can	30,000	3	3	can	9,500
				4	15	can	20,000	4	3	keg	40,000
				5	17	can	22,500	5	3	can	32,500
				6	20	can	20,000	6	6	keg	25,000
				7	20	can	7,500	7	6	keg	40,000
				8	20	keg	25,000	8	6	can	25,000
				9	20	can	30,000	9	6	keg	22,500
				10	20	can	25,000	10	6	can	17,500
				11	20	can	25,000	11	6	can	30,000
				12	22	can	25,000	12	6	keg	30,000
				13	22	can	27,000	13	6	keg	17,000
				14	22	can	19,500	14	6	can	30,000
				15	27	can	20,000	15	9	keg	57,500
				16	27	keg	20,000	16	9	keg	37,500
				17	27	keg	20,000	17	9	can	40,000
				18	27	can	20,000	18	12	can	41,000
				19	27	can	20,000	19	12	keg	20,500
				20	27	can	20,000	20	12	can	20,500
				21	30	can	30,000	21	12	keg	17,500
				22	30	can	25,000	22	12	can	20,500
					July			23	12	keg	22,500
				23	5	can	23,500	24	13	can	25,000
								25	13	can	25,000
								26	13	keg	45,000
								27	15	keg	30,000
								28	15	can	30,000
								29	15	can	20,000
								30	15	can	10,000
								31	15	can	20,000
								32	17	keg	32,500
								33	17	can	32,500
								34	22	keg	25,000
								35	22	can	30,000
								36	22	can	35,000
								37	30	can	30,000
Total	--------		52,500	----------			525,000	----------			1,040,500

[1/] Type refers to type of spawning container used by the spawning adults. Cans were 15- and 10-gallon milk cans painted inside and outside with black asphaltum paint. The kegs were terra-cotta pipe 25 inches long and 14 inches in diameter, with one end boarded closed. They were also painted with black asphaltum.

were adjustable and could be raised or lowered if necessary. Made of metal, 10 inches wide and 4 inches deep, they were activated by a 1/4-horsepower electric motor with 48:1 gear reduction. The shaft activating the paddles made 36 revolutions per minute; thus paddles making 2 sweeps for every revolution passed over the eggs

72 times per minute. Plastic tubing was fastened across the top of the eggs so that they would not float up and be struck by the paddles.

A stock solution of 2 grams of malachite green in 1 gallon of water was made. Ten cubic centimeters of this solution was introduced at the head of each hatching trough every morning and evening.

On several occasions, all 16 egg baskets had eggs; but by the time more eggs were available from the ponds, many of the eggs had hatched, so that empty baskets were available for the new eggs. At no time was there a shortage of egg baskets, as the timing of the spawning and hatching worked out very satisfactorily.

The eggs hatched in about 6 to 7 days. The fry were usually transferred to the rearing troughs about 3 days after hatching--and when they started turning grey. The fry were siphoned from the hatching troughs with a piece of surgical tubing (0.5-inch I) and were caught in a planting bucket that had two screened overflows. The fry were then poured into one of the rearing troughs. About 30,000 fry were put in a trough, but were thinned to around 15,000 as they grew and became crowded. About 40,000 fingerlings were put into the redwood tanks and 150,000 fingerlings into each of the two daphnia tanks.

The fry and fingerlings did best on a diet of raw liver. They were also fed the regular prepared trout pellets, in the fine crumble size, and seemed to do well on the pellets if given some liver once or twice a week. The liver was stored frozen in a large freezer and had to be thawed before being ground through a very fine plate several times. The fish were fed every hour from 8 a.m. to 5 p.m. Night feeding was tried for a short time, but was found to be unnecessary.

Diseases

In 1958 a gas-bubble disease affected the fry, causing their abdomens to become distended so that the fish swam around belly-up, and many died. Three regular perforated trough screens were fixed in a rack, horizontally, 1 inch apart, and placed under the spigots at the head of each trough. The water splashing through these perforated plates seemed to lose the gas or gases which had been causing the trouble. Outbreaks of Ichthyophthirius, Trichodina, and Schyphidia occurred in the troughs and tanks, but weekly treatments with 2 p.p.m. of PMA for 1 hour gave complete control of these outbreaks.

In 1960 an attempt was made to raise channel catfish fingerlings to a larger size in ponds. Fingerlings which were surplus after all allotments had been made were placed in four separate hatchery ponds. Ponds 4, 7, and 8 were 0.32 acre each in size; Pond 17 was 1.4 acres. All of the channel catfish fingerlings placed in Pond 17 had a serious infestation of Ichthyophthirius 3 weeks later. When the sick fingerlings started appearing, they were so badly infested that no treatment was attempted, and the fish were a complete loss. This pond had a seepage from a brood-stock pond, and we believe that it may have been the source of infection. About a month later there was an outbreak of the same disease in Pond 4, and these fish were also a complete loss. This happened after we started using an adjacent pond for holding carp and goldfish as forage for largemouth bass. These forage fish were brought to the hatchery from ricefield drainage canals, and we believe that this was the source of infection for Pond 4. On October 17, 1960, Ponds 7 and 8 were drained and the fingerlings removed for planting. These channel catfish fingerlings were in good condition and showed no signs of any disease. From the 40,000 put in each pond about August 12, 1960, Pond 7 produced 25,050 at 30 to the ounce and Pond 8 produced 25,350 at 13 to the ounce. The fingerlings were from 60 to 100 per ounce when they were put into the ponds.

In 1961, we plan to try raising channel catfish fingerlings in four 0.32-acre ponds, with 25,000 fingerlings in each. Every effort will be made to keep these ponds from being contaminated, and treatment with copper sulfate or sodium arsenite will be tried if the fingerlings become infected with Ichthyophthirius.

Planting the Fingerlings

Transporting channel catfish fingerlings to waters in which they are to be planted offers no difficulties under ordinary conditions. The fingerlings seem to be very hardy and give less trouble when transported than any other species that we have ever handled.

We have transported channel catfish fingerlings in 15-gallon milk cans and in 150- and 250-gallon planting tanks. The cans are aerated with hoses supplied with air from a gasoline-powered compressor. Carborundum stones are fixed to the ends of the hoses in the cans so that the air will be dispersed in very fine bubbles. The planting tanks are aerated by circulating water from perforated pipes on the bottom of the tank to discharge pipes on the top of the tank which spray the water onto the surface. A venturi is placed in the piping system to suck fresh air into the circulating water. Small fingerlings carried in the tanks are placed in fine-screened live boxes which prevent the fish from being sucked through the pumps.

The fingerlings are counted by weighing a sample and counting the fingerlings in it. This gives the number of fish per ounce, and the number of fish needed for a plant are weighed accordingly.

Eight ounces of fingerlings per gallon of water makes a safe load. More can probably be carried, but it is better to load light and get the fish to their destination in good condition than to load heavy and have a loss from overcrowding. We have never experimented to find the maximum load possible with channel catfish, as no need has existed to date.

The ideal temperature in transport seems to be between 65° and 75° F. Ice is sometimes needed if the weather is very hot. Loss in transport is generally negligible. For example, Oregon State workers picked up 36,000 channel catfish at 30 per ounce and released them in Devils Lake on the central coast of Oregon 17 hours later. There was no loss upon arrival. Two groups of 50 fish each were held in live cars for 11 days to check on delayed mortality, but no loss occurred. Other trips of 12 to 14 hours have been made with no difficulties.

The size of the fingerlings planted from the hatchery troughs and redwood tanks has ranged from 350 per ounce to 25 per ounce. The largest fingerlings planted were the fish from Pond 8; these went 13 per ounce. The smallest fish were planted in reservoirs that had been chemically treated and contained either no fish or only small fish of other species.

Summary

The first attempt to raise channel catfish in a California State hatchery was made in 1958. In that year the Central Valleys Fish Hatchery used 8 standard trout-hatchery troughs to raise 121,060 fingerlings and planted them in State waters. In 1959, when equipment for the work was expanded to 20 troughs and two 500-gallon redwood tanks, the hatchery raised and planted 627,440 fingerlings. In 1960, when 20 troughs, 3 redwood tanks, and two 20- by 50-foot concrete tanks were used, the hatchery produced 973,668 fingerlings and planted 686,078.

The hatchery troughs were in a roofed shed. The troughs and tanks were painted with black asphaltum paint and provided with covers to keep light to a minimum.

Water from a deep well was held in a 1.87-acre pond to warm and to absorb oxygen, and then was pumped into the troughs and tanks. Plant life in the pond was controlled with 1 to 2 p.p.m. of a commercial herbicide.

The brood stock (wild fish trapped in the Sacramento River and Sutter Bypass) were held in ponds. Spawning pens with one pair of adults in each were tried, but were unsatisfactory. Spawning containers (10- and 15-gallon milk cans and terra cotta pipe) were painted with black asphaltum paint and placed in each pond. These were checked for eggs by a man who wore a face mask and thrust a gloved hand into each. Eggs were removed from the containers and placed in baskets with a paddle working over them. They were treated twice daily with malachite green to control fungus.

About 3 days after hatching, fry were transferred to rearing troughs.

Outbreaks of Ichthyophthirius, Trichodina, and Schyphidia among fingerlings in the troughs and tanks were controlled by means of weekly treatments with 2 p. p. m. of pyridylmercuric acetate for 1 hour.

An attempt was made to raise fingerlings to a larger size in ponds, but treatment of outbreaks of ichthyophthiriasis was not successful.

Fry and fingerlings were easy to transport. Trips of 12 to 17 hours were made with practically no loss.

The size of fingerlings planted by the hatchery ranged from 350 per ounce to 13 per ounce.

THE BRANDING OF SEA HERRING AS A SHORT-TERM MARK

Branding as a way to identify immature sea herring (Clupea harengus) was one of many marking methods tested at the Biological Laboratory. The device used was a short coil of nichrome heating-element wire--its free ends connected to a 12-volt direct-current power source--laid across the end of an asbestos cement stick. When pressed against a herring body, the white-hot wire instantly burned through scales and skin to make dark parallel lines.

Five-inch herring, freshly branded for identification.

Three lots of ten 5- to 7-inch herring were branded and released with a similar number of controls in laboratory tanks of circulating sea water. The brand was applied laterally in the body area behind and above the pectoral fin. The separate wire marks were burned into the tissue under the scales. The test fish recovered rapidly from the shock of being handled and branded. Initially they broke water, swimming vigorously and erratically, but within a minute all had sounded and joined the controls in a loose school. Scales began to drop off the first day after branding, but the burns under the scales made the mark readily recognizable. After 7 days all marked and control fish had survived; the separate lines of the brand marks had blended into a dark oval patch. One lot of branded fish was held 7 months with no appreciable differences in mortality rates of marked and control fish; the oval scars were still visible but would hardly have been noticed by a casual observer.

The term of readability of marks made by branding can be expected to vary with species. The herring is an unusually delicate fish: its skin and scales can be removed by gentle pressure. Brand marks would probably persist much longer on sturdier species.

For marking herring, branding had several advantages: it was the fastest of all methods tested, the average marking rate exceeding 1,000 fish an hour; wounds healed cleanly, with no mortalities attributable to the method; and the branding wire was easily modified to code various lots of fish. The one drawback was that the individual wire marks were positive only 2 to 3 days: the sloughing of skin and scales in the burned area soon changed the original scar to a dark oval patch. Because of its speedy application, however, branding was later selected for a study of the movement of a large number of herring during two tidal cycles: here the longevity of the mark beyond 25 hours was of no concern.

--JOHN E. WATSON, Biological Laboratory, Bureau of Commercial Fisheries, Boothbay Harbor, Maine.

THE NATIVE FISH POPULATION AND TROUT HARVESTS IN AN ONTARIO FARM POND

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THIS PAPER is a report on an analysis of 10 years of trout angling statistics on a small stream-pond unit in southern Ontario, with particular reference to the standing trout population which was determined after a combination of draining and the application of rotenone in October 1960.

Description of the Pond

The pond is located on a spring-fed headwater stream that has a continuous flow of approximately 9 cubic feet per second and a summer temperature reaching 13° C. above the pond. The surface area is 1.6 acres, and the maximum depth is 8.5 feet. Maximum summer temperatures from 1958 to 1960 reached 14.5° C. at the bottom, 17° C. at the surface. The dissolved-oxygen levels did not fall below 9 p.p.m., and carbon dioxide did not rise above 17 p.p.m. Chara and Elodea were the predominant aquatic plants. During a freshet in 1951 the dam broke and let the water escape from the pond. The pond was back in use the following year.

The natural reproduction in the feeder stream was adequate to maintain populations of brook trout (Salvelinus fontinalis), rainbow trout (Salmo gairdneri), white suckers (Catostomus commersoni), and slimy sculpins (Cottus cognatus), although upstream movement of fish was limited to a distance of approximately 150 yards above the pond.

The Stocking Records

After restoration of the dam, spring plantings of 2-year-old brook trout were made from 1951 to 1955 as follows: 600 in 1951, 500 in 1953, 250 in 1954, and 200 in 1955. The recruitment of trout after that time came from natural reproduction occurring largely in the stream above the pond.

Rainbow trout were resident in the stream system at the time of the breaking of the dam. An unknown number of them were trapped accidentally within the pond-stream unit when the pond was reflooded; through subsequent natural reproduction, a resident population of the species was maintained.

The Fishing Records

Fishing was begun in 1951 after the planting of 600 2-year-old brook trout. Statistics for the 1951-60 period are given in table 1, where catches of brook and rainbow trout are presented collectively because of the possible failure of anglers to distinguish the younger fish of these species from each other.

Records for the 1951-54 period are incomplete, providing information only on the actual harvest of trout, which averaged

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The junior author of this paper has been on loan from the Ontario Department of Lands and Forests.

TABLE 1.--Annual fishing statistics for brook and rainbow trout combined, 1951-60

Year	Man-hours	Total catch			Catch per man-hour			Catch per acre		
		Released	Kept	Total	Released	Kept	Total	Released	Kept	Total
1951	-----	-----	396	-----	---	---	---	---	248	---
1952	-----	-----	323	-----	---	---	---	---	202	---
1953	-----	-----	351	-----	---	---	---	---	219	---
1954	-----	-----	232	-----	---	---	---	---	145	---
1955	124	321	265	586	2.6	2.1	4.7	200	166	366
1956	212	646	333	979	3.0	1.6	4.6	404	208	612
1957	336	883	471	1,354	2.3	1.4	4.0	552	294	846
1958	256	771	244	1,015	3.0	1.0	4.0	482	153	635
1959	172	756	224	980	4.4	1.3	5.7	473	140	613
1960	203	432	338	770	2.1	1.7	3.8	271	211	482
Total 1955-60	1,303	3,809	1,875	5,684	---	---	---	---	---	---
Mean 1955-60	217	635	313	947	3.0	1.4	4.4	397	195	592

326 fish annually. The relative contribution of hatchery-reared and naturally produced trout to the harvest cannot be determined.

Records for the 1955-60 period provide statistics on the annual fishing pressure and the resulting numbers of fish caught, kept, and released. These data appear in table 1. During this period 1,303 man-hours of angling were used to catch 5,684 trout, of which 1,875 (33 percent) were retained and the balance returned to the water. This represents a harvest of 1.4 trout per man-hour from a catch of 4.4 fish per man-hour. The catch was predominantly brook trout, with rainbow trout making up less than 3 percent of the actual harvest for the period.

Until 1960, when the length limit was abolished in Ontario, the harvest was restricted to trout having total lengths of no less than 7 inches. For the purpose of this analysis, the catch for 1960 has been arbitrarily divided also into trout above and below a total length of 7 inches. A breakdown of the total catch on this basis for the 1956-60 period is given in table 2, in which it is shown that 1,179 man-hours of angling were used to catch 5,098 trout.

Of the total catch, 57.9 percent of the trout were less than 7 inches in length. On acccunt of the selectivity of the baits that were used, fish less than 5 inches in length were seldom taken by angling; hence the trout of "sublegal" size were largely in the 5- to 7-inch range. This catch of 2,950 represents the number handled, as individual trout may have been recaptured once or more during the fishing season.

Although the legal length limit of 7 inches gave anglers the privilege of keeping 2,148 trout between 1956 and 1960, only 75 percent of the trout over this length were actually harvested (kept). Most of those trout rejected were in the 7- to 8-inch range, at a size below that preferred by most anglers fishing the pond. The comparatively low rejection rate of 10.8 percent occurred in 1960, when the anglers were encouraged to increase their harvest of smaller trout. This emphasis on the retention of more trout in the 7- to 8-inch range contributed also to the harvest of 43.9 percent of the total catch of fish of all sizes--a harvest which was considerably above the 28.9-percent average for the preceding 4 years.

The Standing Fish Population

Species Composition, October 1960

The standing fish population in the pond during October 1960 included four species. These were the brook trout, the rainbow trout, the white sucker, and the slimy sculpin. Table 3 shows a total count of 2,857 fish of all species, which included 1,094 (38.3 percent) brook trout, 152 (5.3 percent) rainbow trout, 1,553 (54.4 percent) suckers, and 58 (2.0 percent) sculpins. The aggregate weight of these fish was 761.4 pounds, comprising 63.4 pounds (8.3 percent) of brook trout, 18.9 pounds (2.5 percent) of rainbow trout, 676.8 pounds (88.9 percent) of suckers, and 2.3 pounds (0.3 percent) of sculpins. This represented a standing fish population weighing 475.9 pounds per acre at the close of the fishing season.

Size Composition

The size-composition curves for each of the major fish species in October 1960 are shown in figure 1. An analysis of the numbers of fish of all species shows that those in the 2.0- to 3.9-inch range made up 42.5 percent of the aggregate population. All brook trout except one 11.8-inch fish were between 2.0 and 10.9 inches in length and represented 44.6 percent of the aggregate population of all species within this size range. Of the remaining fish under 11 inches in length, 49.7 percent were suckers and 5.7 percent rainbow

TABLE 2.--Catch and harvest statistics for brook and rainbow trout combined, 1956-60

Year	Fishing intensity (man-hours)	Catch statistics: Length under 7 inches: Number	Catch statistics: Length under 7 inches: Percentage of catch	Catch statistics: Length over 7 inches: Number	Catch statistics: Length over 7 inches: Percentage of catch	Total catch	Harvest statistics: Number	Harvest statistics: Percentage of catch: Over 7 inches	Harvest statistics: Percentage of catch: Total
1956	212	582	59.4	397	40.6	979	333	83.9	34.0
1957	336	634	46.8	720	53.2	1,354	471	65.4	34.8
1958	256	646	63.6	369	36.4	1,015	244	66.1	24.0
1959	172	697	71.1	283	28.9	980	224	79.2	22.9
1960	203	391	50.8	379	49.2	770	338	89.2	43.9
Total	1,179	2,950	----	2,148	----	5,098	1,610	----	----
Mean	236	590	57.9	430	42.1	1,020	322	75.0	31.6

TABLE 3.--The resident fish population in the pond, October 1960

Species	Number: Under 7 inches	Number: Over 7 inches	Number: Total	Weight in pounds: Total	Weight in pounds: Per acre	Percentage of total: By number	Percentage of total: By weight
Brook trout------	974	120	1,094	63.4	39.6	38.3	8.3
Rainbow trout----	121	31	152	18.9	11.8	5.3	2.5
White sucker-----	807	746	1,553	676.8	423.0	54.4	88.9
Slimy sculpin----	58	---	58	2.3	1.4	2.0	.3
Total---------	1,960	897	2,857	761.4	475.8	100.0	100.0

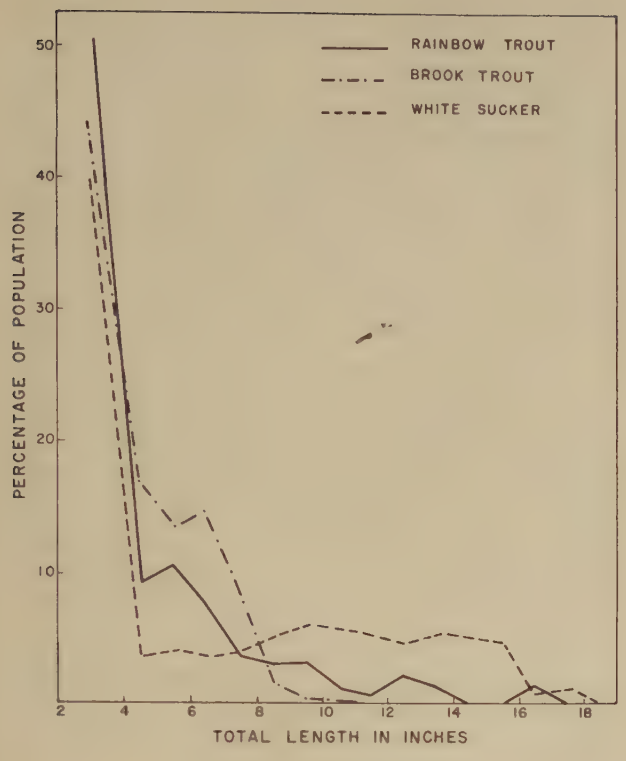

FIGURE 1.--The size composition of the brook trout, rainbow trout, and white sucker populations, October 1960.

trout. Of the fish more than 11 inches in length, 98.2 percent were suckers, 1.8 percent rainbow trout.

A comparison of the size composition of the brook and rainbow trout populations shows that fish less than 7 inches in length made up 89.0 percent and 79.8 percent, respectively, of the population of each species. Trout in the 7.0- to 7.9-inch length range and too small to be preferred by local anglers formed 14.6 percent and 8.4 percent of the respective populations. Trout more than 8 inches long and of the size preferred by anglers made up 11.0 percent of the brook trout population and 20.2 percent of the rainbow trout population. However, comparison of the actual numbers of rainbow and brook trout shows that of the combined population of the 45 fish over 8 inches in length, nearly half (48.8 percent) were rainbow trout, although this species made up only 10.9 percent of the total population of trout of all sizes at the end of the fishing season.

Growth Rates

Growth studies were made of the brook trout, rainbow trout, and common suckers collected during October 1960. Ages of the fish were determined by examination of body scales. The age-length curves, computed by back-calculation and direct measurement of fish of all sizes, are presented in figure 2-a.

From a comparison of the length-age curves for brook trout and rainbow trout it is apparent that these species grew at approximately the same rate during the first year of life. In subsequent years, however, the rainbow trout grew more quickly; and by October of the fourth year

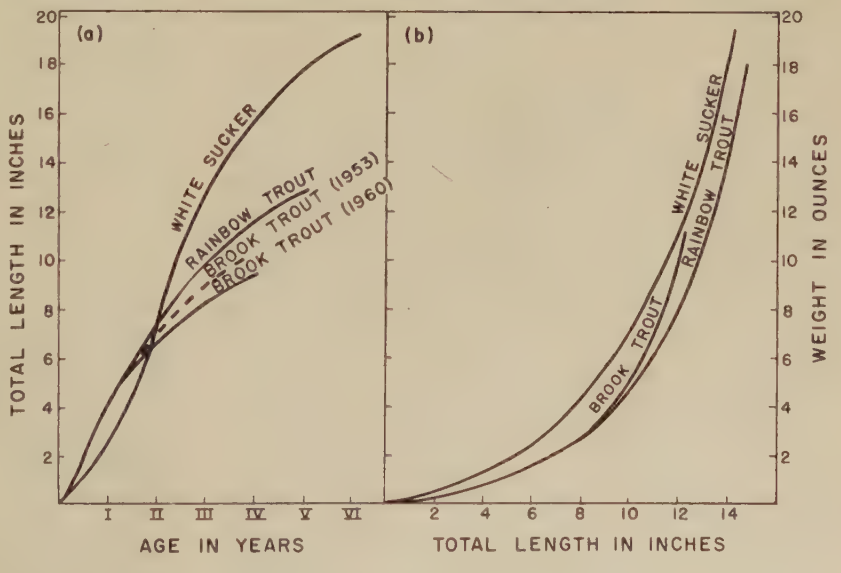

FIGURE 2 a,b.--Growth curves for the brook trout, rainbow trout, and white sucker. Specimens and scales taken, October 1960.

the average length of the brook trout was only 71 percent of that of the rainbow. The largest brook trout taken measured 11.8 inches; the largest rainbow, 19.7 inches. A comparison of these growth rates with those observed for trout in other Ontario ponds by Ricker (1932), Harkness (1941), and the present authors (unpublished) reveals the species in this pond to be below average in growth.

The common sucker grew more slowly than either of the trout species during the first year of life but reached a greater length by October of the second year and continued to have a higher growth rate after that time. Several suckers which were collected measured between 19.0 and 19.9 inches in length.

The length-weight relations of the three species are shown in figure 2-b. A comparison of the curves reveals that at all total lengths greater than 1.5 inches, the common sucker was heavier than either species of trout. The brook and rainbow trout were characterized by a similar length-weight relation up to a length of about 7 inches. At greater lengths, the increase in weight per unit of length was higher for the brook than for the rainbow trout, though the rainbow trout ultimately reached a considerably greater length and weight.

Age and Maturity

The brook trout began to reach sexual maturity at lengths of 5 to 6 inches during the second year of life. Approximately 40 percent of the trout of this size which were examined in October previous to spawning were mature. Some 90 percent of the 7- to 8-inch fish in their third year, and all of the trout over 8 inches and in their fourth and fifth years, were mature. Very few brook trout reached their fifth year, and no older trout were in the pond in October.

The rainbow trout were slower to reach maturity than the brook trout. Some fish of both sexes, but predominately males, reached maturity at 7.5 to 9 inches in length during their third year of life. All rainbow trout were mature by their fifth year. No trout beyond their seventh year were in the pond.

The white suckers of both sexes first reached maturity at a length of about 8 inches during their third year of life. The majority were mature the following year. A number of suckers in their seventh year of life were in the pond in October, though no older suckers were there.

Exploitation Rates

A calculation of the virtual population of trout of a size acceptable to anglers at the beginning of the 1960 fishing season (May 1) provides a basis for appraising the level to which the standing population was exploited by seasonal angling. This virtual population has been calculated by adding the number of trout harvested during the fishing season to the standing population of trout over 7 inches in length in October. No account has been taken here of natural mortality, which is discussed in a subsequent section.

On this basis, the virtual population of trout available for harvest (that is, fish over 7 inches in length) on May 1 was 452 brook trout and 43 rainbow trout, or 30 percent of the total population of trout of all sizes. During the fishing season that followed, 34.9 percent of the rainbow trout and 74.8 percent of the brook trout were harvested during 203 man-hours of angling. The relation between annual fishing effort, catch, and harvest level from 1955 to 1960 is shown in figure 3.

Mortality of Trout

An analysis of the composition of the standing trout population in October 1960 has provided some indication of the mortality that occurred in the pond from one October to the next. A comparison of the numbers of trout (brook and rainbow trout combined) in each year-class suggests an annual total mortality rate of about 60 percent from young-of-the-year to yearlings and from yearlings to 2-year-old fish, and about 94 percent from 2-year-old to 3-year-old fish. The fishing mortality among trout over 7 inches in

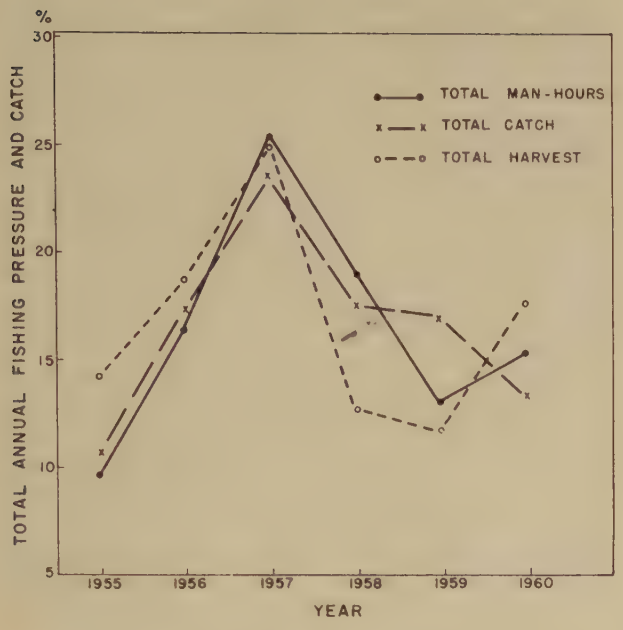

FIGURE 3.--The relation between the annual fishing effort, catch, and harvest levels, 1955-60.

length, estimated previously to be no less than 71.4 percent of the pre-fishing-season population of fish of this size, contributed substantially to the high mortality rate for older trout. No quantitative information is available on egg production nor on the survival of the hatch through the first year of life.

Discussion

Natural reproduction of brook trout, rainbow trout, white suckers, and slimy sculpins in the inflowing creek has maintained populations of each of these species. With the possible exception of the brook trout, the present population of each species has had its origin solely in fish resident in the stream before reconstruction of the dam and reflooding of the pond in 1951.

It is probable that the progeny of both the native and the 2-year-old hatchery-reared brook trout planted in the pond between 1951 and 1955 contributed to the present population of that species. The standing population of brook trout since 1958 has been solely the result of natural reproduction. The rejection by anglers, in 1955 and 1956, of numerous small trout below the size of the planted hatchery-reared trout is evidence that natural reproduction was contributing significantly to the brook trout population. The discontinuance of trout plantings after 1955 has had no obvious adverse effect on the quality of angling, as may be seen from the catch-per-man-hour data in table 1.

The level of the rainbow trout population has remained low in comparison to that of the brook trout. Rainbow trout made up only 2.5 percent of the total harvest of 3,177 trout between 1951 and 1960, and the standing population in October 1960 was only 13.8 percent of that of the brook trout, although both species had the same spawning areas available to them. It would seem that the plantings of the brook trout after the reflooding of the pond established a numerical dominance of this species which continued to 1960. Other ecological and biological factors may have contributed also to the difference in the population levels of the two species.

The white sucker may have been in the pond before 1950 or may have ascended from the stream below when the dam was out. Regardless of origin, a small population of suckers was trapped in the pond when it was reflooded in 1951. By 1960, suckers made up 54.4 percent of the numbers of the total population and 88.9 percent of the weight of fish of all species, contributing 423 pounds per acre to the standing October population. The effect of the sucker population on the welfare of the trout has not been investigated, though it is suspected that the conversion of nutrients to sucker growth may be a factor related to the slow growth of brook trout. A comparison of 1953 and 1960 growth rates of brook trout (figure 2) has shown a slower growth rate in 1960, and this correlates with the increase in the sucker population during the interval. However, hatchery-reared fish were included in the 1953 analysis and may have accounted for the higher growth rate there. The possible contribution of small suckers to the food of the trout should not be overlooked.

The low October population of sculpins, forming only 2.0 percent by number and 0.3 percent by weight of the total fish population, is insignificant in the population dynamics of the pond. The extent to which predation by trout keeps this species in check is not known.

An analysis of data on fishing intensity, catches, and harvests of trout (table 1) revealed a large variation in the annual levels of each. During the 1951-60 period, when 3,177 trout were harvested, the annual harvest varied as much as 48.1 percent from the mean harvest of 317.7 trout. During the 1955-60 period, for which more complete statistics are available, fishing intensity varied as much as 54.8 percent from the annual mean of 217 man-hours. Annual total catches varied as much as 43.3 percent of the mean annual catch of 947 trout, and annual harvests as much as 50.4 percent of the mean annual harvest of 313 trout. Of particular interest is the fact that, despite the large annual variation in the levels of each of these items, there is a strong correlation between man-hours of fishing and both the total catch and the harvest of trout. This has been illustrated in figure 3. On the basis of this correlation, it may be concluded that catch and harvest levels were more dependent on the extent of angling activity than on the level of the standing trout population. Annual fluctuations in the trout population no doubt occurred, but there is no suggestion that angling was sufficiently extensive to exploit the available trout population to the point that it became apparent in the catch statistics.

Details on the exploitation of the trout population by angling have been provided by data collected during 1960. A comparison of the calculated initial trout population of May 1 (excluding natural mortality) with subsequent harvests revealed that of the numbers of each species of a size acceptable to anglers at that time, some 34.9 percent of the rainbow trout and 74.8 percent of the brook trout, or 71.4 percent of the species combined, were harvested at an angling intensity of 127 man-hours per acre. From these data, brook trout would seem to have been about twice as susceptible to angling as the rainbow trout, although the relatively few rainbow trout may have affected the respective levels of exploitation of the two species.

In view of the observed correlation of fishing pressure with harvest levels and the lack of any evidence of overfishing in the catch and harvest statistics, it may be concluded that the level of exploitation exerted annually on the trout population left adequate spawning stock to maintain, through natural reproduction, population levels in excess of angling requirements.

The productivity of trout ponds is expressed often in terms of trout harvests. However, because of (1) underfishing and (2) the arbitrary selection of only "keeper" trout of a preferred size from the catch, harvest statistics for trout ponds seldom give a true picture of maximum potential harvest levels. Both of these factors are apparent in the pond under discussion. Concerning the first factor, the average annual 1955-60 harvest per acre of 196 trout (or 35.6 pounds) does not represent the highest exploitation level possible by angling. Increased angling would be expected to increase the harvest further, although the 1960 harvest of approximately 70 percent of the available trout may be approaching the maximum level of exploitation of the fishery on a sustained yield basis. Concerning the second factor, it is apparent from table 2 that anglers elected to keep from 65.4 to 89.2 percent of those trout over 7 inches in total length taken between 1956 and 1960. The peak figure of 89.2 percent in 1960 resulted from encouragement given to anglers to harvest more of the smaller trout. Some anglers harvested all trout over 7 inches in length; others preferred to return the smaller trout to the water.

An examination of the statistics presented permits some observations of general interest on the catch, harvest, and quality of angling provided by the naturally reproducing trout population. The 1960 population study revealed that after anglers had harvested 364 of the brook and rainbow trout, there remained a standing population of 1,246 trout of all sizes weighing an aggregate of 82.3 pounds, or

51.4 pounds per acre. Of these fish, 12.1 percent were over 7 inches in length. By a comparison of the calculated virtual population in May with the subsequent harvest, it was shown that no more than 71.4 percent of these trout of the size preferred by anglers for harvest were removed by 203 man-hours of angling.

Catch statistics for the 1956-60 period, when 5,098 trout were caught in 1,179 man-hours of angling, showed that 42.1 percent of these fish were over 7 inches in total length, although only 1,610 fish (or 31.6 percent of the catch) were kept. The average annual harvest during the period was 201 trout per acre, weighing approximately 39 pounds per acre. The quality of fishing during this 5-year period may be expressed as a catch of 4.4 trout per man-hour and an actual harvest of 1.4 trout per man-hour of angling.

Acknowledgments

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EASIER COMMUNICATION DURING BOAT SHOCKING OPERATIONS

One of the well-known difficulties during "in-boat" shocking operations arises from the lack of easy communication between the man who is operating the outboard motor at the stern and the man whose job it is to dip fish from the bow. When the boat is being run in shallow water, it is desirable for the man at the bow to give warning of rocks, logs, and other debris that might damage the propeller or motor; when the boat is being moved into shorelines and coves at night, it is well for the man stationed at the bow to notify the motor operator quickly of any boom and electrode tangles; and when fish are sighted from the bow, it will be easier to collect them if the motor operator is told their position. Shouts and signals are often inadequate as a means of conveying information rapidly.

The necessity for shouting important information above the racket produced by the motor and generator, as well as the possibility of some delay or confusion, may be eliminated by having the crew use Navy-surplus sound-powered telephones. The operator of the motor and the man who is working in the bow need only be supplied with head sets equipped with receivers and transmitters. The wire connecting the two head sets may be of any length, provided that it is at least as long as the boat. There is no difficulty in the operation of these telephones, and any message between the bow and the stern can be transmitted by simply pushing a button.

--JAMES D. STEWART, Vermont Fish and Game Service, Montpelier, Vermont.

MICROHEMATOCRIT VALUES IN RAINBOW TROUT, BROWN TROUT, AND BROOK TROUT

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HESSER (1960) reviewed the literature on the examination of fish blood and discussed the diagnostic value of such an examination. Hunn (1960) prepared a bibliography of the chemistry of fish blood. Snieszko (1960) described in detail a microhematocrit procedure and microhematocrit values as obtained with trout blood. Larsen and Snieszko reviewed and evaluated methods of hemoglobin determination (1961-a) and discussed modification of the microhematocrit procedure applied to fish blood (1961-b).

The purpose of this paper is to furnish additional data on hematocrit values in trout, in order to contribute to the establishment of normal values for brook, brown, and rainbow trout of different sexes and age groups.

The technique employed here was the same as that described by Snieszko (1960). Commercially available heparinized capillary tubes, 75 millimeters long and 1.3 to 1.5 millimeters wide, were used. Fish were anesthetized rapidly with tricaine methanesulfonate (M.S. 222), and blood was collected directly into tubes from the severed caudal peduncle.

Hematocrits for the majority of 2-year and older trout were run in connection with the survey made to determine the presence of visceral tumors in trout at certain National fish hatcheries.

Results

Data are presented in six tables which, in the author's opinion, contain all of the pertinent information that may be needed for comparison with similar data already published or to be published.

In July 1959, all production trouts at this station were transferred from the wet Cortland diet No. 6 to pellets. Hematocrit and hemoglobin determinations were run on 10 trout of each species, at intervals of about 1 month. These tests were run from July 1959 to May 1960. Results (table 1) show that hematocrit values were about the same for brook and rainbow trout but somewhat lower for brown trout. Hemoglobin values (not shown in the table) were in close quantitative relation to the hematocrits.

Hematocrit values for fingerling rainbow and brown trout as well as for 1- and 2-year-old brook trout, determined in connection with electrophoresis of trout blood, are presented in table 2. Values for rainbow and brown trout are very close to those presented in table 1, but are much lower for brook trout. This may be due to a high incidence of visceral granuloma (table 3) in brook trout. It is interesting to note that though there are no significant differences in mean values for both sexes of brook trout, there is a difference in frequency distribution (table 2).

Hematocrits were determined for more than 600 rainbow, brook, and brown trout, 1 to 5 years old, during September and October 1960. This work was done in connection with a survey made to determine the presence of hepatoma and other visceral tumors in the trout at certain

TABLE 1.--Hematocrit determinations made for quality control of production trout at the Leetown National Fish Hatchery

Date of examination	Rainbow trout[1/]		Brook trout[1/]		Brown trout[1/]	
	Hematocrit	Standard deviation	Hematocrit	Standard deviation	Hematocrit	Standard deviation
1959						
July 1	45.5	2.17	46.7	1.69	33.8	3.37
Aug. 1	49.3	4.12	56.0	5.50	45.4	2.86
Oct. 1	46.0	3.16	48.5	5.61	41.9	2.51
Nov. 3	48.0	7.21	47.7	8.22	36.0	3.16
Nov. 27	50.0	4.04	49.6	4.75	41.0	6.94
1960						
Jan. 4	53.0	4.26	49.2	4.17	45.4	4.02
Feb. 2	48.4	5.26	56.0	4.65	36.0	3.19
Mar. 1	48.3	5.80	53.6	4.22	37.0	3.55
May 1	43.8	4.34	48.6	3.25	----	----
Mean	47.8	4.50	50.7	4.66	39.5	3.70

[1/] Each sample consisted of 10 trout selected at random. Beginning in December 1958, all were fed liver. This was followed by beef liver and spleen with dry Cortland mix. From July 1, 1959, all were fed pellets only.

TABLE 2.--Hematocrit values in rainbow, brook, and brown trout selected at random from production trout at the Leetown National Fish Hatchery in 1958-59

Species	Age	Sex	No.	Hematocrit mean value	Standard deviation	Frequency distribution of hematocrit values (percent of total)							
						25 or less	26-30	31-35	36-40	41-45	46-50	51-55	56 or more
Rainbow	3-10 months	(1/)	84	44.7	7.04	0.0	3.6	4.8	14.3	29.8	28.6	15.5	3.6
Brook	3-10 months	(1/)	68	41.5	7.14	5.9	2.9	1.5	22.0	38.2	26.5	2.9	0.0
Brook	1-2 years	♂	41	41.4	9.54	5.0	2.5	12.2	19.5	24.4	26.8	7.3	2.5
Brook	1-2 years	♀	46	41.5	8.00	4.3	8.7	4.3	21.8	30.4	21.8	6.5	2.2
Brown	4-10 months	(1/)	48	41.7	7.21	0.0	0.0	2.4	32.7	53.0	12.5	0.0	0.0

[1/] Sex undetermined.

TABLE 3.--The occurrence of mycosis-like granuloma in brook trout raised at the Leetown National Fish Hatchery and Eastern Fish Disease Laboratory in 1957-59

Strains of trout[1] and age groups	Trout examined (number)	Granuloma present[2] (percent)
Walhalla, S. C.		
Yearlings	42	40.0
Bellefonte, Pa.[3][4]		
Fingerlings	40	5.0
Yearlings	65	12.5
Two years	10	30.0
Beaver Creek, Md.[4]		
Yearlings	32	47.0
Berlin, N. H.		
Yearlings	29	38.0

[1] All trout were fed Cortland diet No. 6. All trout had pancreatic necrosis when in fry stage.

[2] Gross examination.

[3] A relatively slow-growing strain of brook trout.

[4] Resistant to furunculosis and ulcer disease.

National fish hatcheries. The presence of hepatoma did not seem to have an effect on the hematocrit value. In sexually mature trout of all three species, significant differences were found between the sexes (tables 4, 5, and 6). The values were significantly lower for all females except one lot of brook trout, and this was such an exceptional case that it could safely be attributed to an error in recording.

Another interesting observation concerned the effect of storage of wet mixed diet on the development of anemia in brook trout. In the summer of 1959, at the Leetown National Fish Hatchery, trout that had been receiving the Cortland diet No. 6 (50 percent dry mix and 50 percent mixture of frozen beef liver and beef spleen) were shifted to a pellet diet without any fresh meat supplement. As some of the brook trout were being kept under observation in connection with an experiment of a different nature, it was believed that it would be better to maintain these trout on an unchanged diet. For this purpose a large batch of the Cortland diet was prepared, distributed into metal cans, and stored in a freezer. When needed, one can at a time was removed and kept in a refrigerator for a week to 10 days until all the food was used. This procedure was followed from early in July 1959 to early in February 1960, during which time the appearance and behavior of the trout were apparently normal. In February it was noticed that all the trout were becoming sluggish and that their gills were pale. Therefore, a number of the trout were selected at random and examined. The hematocrit values for these trout were as follows:

Mean value for--	
All 33 trout	19.2
22 males	23.0
standard deviation	9.08
11 females	12.6
standard deviation	6.02
Difference between sexes	45%

Discussion

Observations that were reported by Snieszko (1960) indicated that if commercial heparinized capillary tubes are used, hematocrit values for trout blood may be somewhat higher because of occasional incomplete prevention of blood clotting. For this reason the hematocrit values reported in this paper may be somewhat higher than those which would be obtained by using tubes treated with a 10-percent solution of heparin (Larsen and Snieszko, 1961-b). If, however, hematocrit values recorded for various species, lots, and sexes of trout are compared with each other, the error caused by the use of commercial capillaries can be considered of little significance.

It is interesting to note also that there are significant differences between the sexes in sexually mature trout. This is an important fact to keep in mind when a hematological examination of sexually ripe fish is made, so that differences in

TABLE 4.--Hematocrit values in rainbow trout

Lot number	Hatchery	Date of examination	Age (months)	Sex	Number examined	Hematocrit value	Standard deviation	Difference between sexes (percent)
7-M-1	Manchester, Iowa	9/21/60	60	♂	18	56	7.2	19.5
				♀	12	45	8.6	
8-M	---do.---------	9/21/60	36	♂	17	54	6.0	20.0
				♀	13	43	4.3	
55-Cr	McNenny, S. D.	10/ 5/60	60	♂	8	46	7.7	26.0
				♀	17	34	5.4	
8-EB	Erwin, Tenn.	9/ 8/60	33	♂	7	50	2.46	14.0
				♀	8	43	1.61	
8-NC	New Castle, Va.	9/ 7/60	33	♂	20	57	8.70	17.5
				♀	13	47	7.75	
6-NC	---do.---------	9/ 7/60	57	♀	8	45	6.08	----
9-W	Wytheville, Va.	9/ 8/60	22	♂	7	45	3.60	6.7
				♀	8	42	3.74	
8-W-1	---do.---------	9/ 8/60	34	♂	15	57	8.60	19.3
				♀	6	46	4.79	
8-WHW-1	Walhalla, S. C.	9/14/60	27	♂	8	55	2.12	23.6
				♀	15	42	3.56	
9-WHW-1	---do.---------	9/15/60	16	♂	7	48	5.90	6.3
				♀	3	45	1.00	
9-N	Norfork, Ark.	9/20/60	18	♂	7	49	6.32	14.3
				♀	8	42	4.24	
9-Cal	---do.---------	9/21/60	20	♂	6	43	2.45	18.6
				♀	10	35	2.91	
8-W	---do.---------	9/21/60	35	♂	10	49	5.20	18.4
				♀	15	40	4.15	
9-P-2	Pisgah Forest, N. C.	9/12/60	18	♂	7	48	3.56	14.6
				♀	8	41	4.69	
8-W-1	---do.---------	9/10/60	31	♂	10	54	5.47	16.7
				♀	10	45	7.41	
100	Nashua, N. H.	9/15/60	44	♂	7	48	8.88	10.4
				♀	16	43	5.10	
9-Cal	Pittsford, Vt.	9/26/60	20	♂	12	40	2.6	2.5
				♀	14	39	4.6	

Mean values: for males, 50.0; for females, 42.2. Difference (percent), 15.6.

TABLE 5.--Hematocrit values in brook trout

Lot number	Hatchery	Date of examination	Age (months)	Sex	Number examined	Hematocrit value	Standard deviation	Difference between sexes (percent)
9-WH-1	Walhalla, S. C.	9/14/60	18	♂	10	42	5.36	-12.0
				♀	10	37	4.44	
7-P-1	Pisgah Forest, N. C.	9/13/60	18	♂	25	44	5.56	- 9.1
				♀	21	40	5.37	
8-B	Berlin, N. H.	9/19/60	32	♀	22	38	3.90	-----
9-B-1	---do.---------	9/19/60	20	♂	10	1/32	3.30	1/+10.1
				♀	10	1/36	3.40	
6 and 7-B	---do.---------	9/19/60	43 and 54	♂	7	46	6.10	- 8.7
				♀	17	42	4.20	
8-P	---do.---------	9/19/60	32	♂	16	49	6.20	-32.6
				♀	9	33	5.50	

Mean values: for males, 45.2; for females, 38.0. Difference (percent), 16.0.

1/ Not included in the calculation of mean values; see text for explanation.

TABLE 6.--Hematocrit values for brown trout

Lot number	Hatchery	Date of examination	Age (months)	Sex	Number examined	Hematocrit value	Standard deviation	Difference between sexes (percent)
51-Ct	McNenny, S. D.	10/ 5/60	?	♂	9	41	3.70	14.6
				♀	16	35	7.30	
9-P-1	Walhalla, S. C.	9/15/60	18	♂	9	48	4.47	27.0
				♀	5	35	2.80	
8-C-1	Cortland, N. Y.	9/13/60	34	♂	8	41	2.70	9.8
				♀	7	37	2.30	
7-C	---do.---------	9/13/60	45	♂	9	45	3.90	13.3
				♀	6	39	4.70	
8-C	---do.---------	9/13/60	34	♂	11	44	6.70	4.8
				♀	4	42	4.10	
7-C-1	---do.---------	9/13/60	45	♂	10	44	6.10	4.8
				♀	5	42	5.10	

Mean values: for males, 44.0; for females, 38.3. Difference (percent), 13.0.

hematocrit values due to sex may not be attributed to other causes.

Summary

Hematocrit values were determined in a large number of brook, brown, and rainbow trout of various age groups and of both sexes. The fish were at hatcheries distributed over a large area and were exposed to different conditions and feeding.

The mean hematocrit values are lowest in the brown trout and highest in the rainbow trout. In sexually mature trout, the hematocrit values are significantly higher in male fish. It is believed that the data here presented will help to establish normal values for trouts.

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UTILIZATION OF SPAWNING BOX BY BASS

There have been numerous instances of unsuccessful reproduction by bass in small, often silt-laden lakes and ponds. The literature suggests that placement of gravel at suitable sites may be beneficial.

When Bear Lake (8 acres) and Rock Lake (4 acres) in West Virginia were drained and treated with rotenone in 1959, the bottoms consisted almost entirely of knee-deep silt and muck. Young-of-the-year bass were lacking. Twenty-nine wooden boxes, each 2 feet by 2 feet by 4 inches, were constructed, partly filled with gravel, and placed in 2 to 3 feet of water along the shorelines of these lakes. Bear Lake was then restocked with adult largemouth bass and bluegills, and Rock Lake was stocked with smallmouth bass.

Observations during the spring and early summer of 1960 revealed that both largemouth and smallmouth bass utilized the spawning boxes extensively but did not attempt to spawn anywhere else in either lake. An abundance of bass fry was seen in each lake. It was evident that the bass sought suitable sites, and that they found and preferred the spawning boxes.

--DAVID W. ROBINSON, West Virginia Conservation Commission, Middlebourne, West Virginia.

It has not been proved that the high egg yield of hatchery trout is actually hereditary.

ACTIVE PREDATION OF CRAYFISH ON FISHES

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CRAYFISH are generally considered to be saprophagous (Pennak 1954); there are few published observations on crayfish actively feeding on fishes. This paper records some instances of predation by two species of crayfish, Orconectes nais (Faxon) and Cambarus bartoni (Fabricius), on various fishes, some of which were partly incapacitated by rotenone or by electrical shock. The observations in Kansas were made by Minckley while he was employed by the State Biological Survey of Kansas, University of Kansas, Lawrence.

Observations

Our most detailed observations were made in the upper reaches of Doe Run, Meade County, Kentucky. Doe Run is a spring stream rising east of Ekron and entering the Ohio River about 4 miles upstream from Brandenburg, Kentucky. The upper portion of Doe Run is characteristic habitat of C. bartoni (Rhoades 1944), with a constant temperature and flow of water. A large population of the crayfish exists in the stream, and individuals as large as 200 millimeters in length (from tips of chelae to tip of appressed telson) and 90 grams in weight are common. All of the incidents described in this paper occurred after the area had been shocked by routine collecting procedure. The electrical units used were 115-volt 300- to 600-watt alternating-current generators, equipped with either "pole" electrodes or a 30-foot 6-electrode "seine."

When shocked, the crayfish reacted with a rapid, convulsive, backward movement; however, on no occasion have we observed crayfish immobilized with our shocking gear. White suckers, Catostomus commersoni (Lacepédè), which were commonly taken, reacted either by violent movements at the surface or by rapid movements near the bottom until they entered the electrical field, where they were immobilized. The blacknose dace, Rhinichthys atratulus (Hermann), almost invariably exhibited the latter type of reaction. Both species of fish typically regained equilibrium in 3 to 5 minutes, but approximately 20 percent of all the fish observed were incapacitated for periods of as much as 30 minutes. We know of no actual fish mortality from the use of our equipment, but about 10 percent of the fish were in an apparently moribund condition when preserved.

The first observations were made on November 22, 1959, in a pool about 2 feet deep. This incident was observed about 10 minutes after the shocker pass had been completed. A white sucker was seen moving slowly near the bottom, apparently just regaining its equilibrium. A single C. bartoni moved alongside the fish on the

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right until it reached the level of the pectoral fin. Then the crayfish moved rapidly toward the fish, causing it to dart away in a complete turn. The crayfish followed and approached the left side of the sucker, immediately grasping the pectoral fin with one chela. The fish rolled on its right side, gyrated rapidly for two or three turns, and then slowed. The crayfish at once grasped the right pectoral fin with the other chela. The fish began to move in a tight circle, while the crayfish clung tenaciously to the fins. After 2 or 3 minutes, three more C. bartoni approached and grasped the remaining fins. With the sucker still moving slowly in a circle, the crayfish began dissecting it with their chelae and feeding actively. At this point the fish was netted, with the crayfish maintaining their holds until manually removed. The fish was 13.4 inches in total length and weighed 340 grams.

FIGURE 1.--Effects of crayfish predation on fishes: (A) blacknose dace: maximum exposure to crayfish, 10 minutes; (B) white sucker: alive when netted, but note the frayed fins which resulted from being held to the bottom by crayfish; (C-D) white sucker: maximum exposure to crayfish, 15 minutes. Note the consistent damage to the fins and the removal of the lips (C-D), viscera (A), branchial apparatus (A, C-D), and caudal peduncle (A, C-D).

A second series of observations was made on April 15, 1960, in the same area. A few minutes after a shocker pass had been made, three C. bartoni were found feeding on a blacknose dace. The fins of the dace had been largely removed, the fish was eviscerated, the skin had been removed, and much of the muscle consumed (figure 1, A). It is probable that this fish was attacked after being totally immobilized by the electrical shock.

A short time later, a large pool (30 feet in diameter and 4 feet in depth) was shocked. Eight white suckers were obtained in the initial pass; all were in good condition shortly after collection. After 15 minutes the pool was again examined and three suckers were netted from the bottom. One of these was undamaged and moved vigorously when netted; the other two had been attacked by crayfish, however, and one of these fish was dead. Crayfish had been seen feeding on the latter specimens prior to their capture, and three C. bartoni were netted with these two fish. The living, but damaged, sucker had appeared to be held to the bottom by crayfish just before it was netted; the fins were frayed and partly consumed

(figure 1, B). The dead specimen had been largely dissected: the lips, gills, and fins had been removed to some degree; and the caudal peduncle skinned and partly removed (figure 1, C-D). About 40 minutes after the original collection in this pool, we noted the floating air bladder of a white sucker. Probably the air bladder had been released in the course of ingestion of a fish by crayfish.

In May 1958, Minckley applied rotenone to a small pond in Franklin County, Kansas. The pond contained golden shiners, Notemigonus crysoleucas (Mitchill), fathead minnows, Pimephales promelas Rafinesque, and green sunfish, Lepomis cyanellus Rafinesque, plus a large population of the crayfish Orconectes nais. Soon after application of the rotenone, activity of the fish in the shallow areas of the pond was obvious, as was the predation by the crayfish on the fish. Crayfish virtually covered the bottom in the shallow areas, and were actively pursuing, catching, and eating the distressed fish. Within 1 hour the downwind side of the pond was littered with floating air bladders, which were apparently released undamaged as the fish were consumed.

In June 1957, Minckley made one observation of O. nais preying on young-of-the-year black bullheads, Ictalurus melas (Rafinesque), that had not been injured by collecting procedures. The observation was made in Otter Creek, Cowley County, Kansas. A school of young black bullheads was seen swimming near a limestone ledge on which a large O. nais was situated. As the small fish approached the ledge, the crayfish scrambled toward them and launched itself forward into their midst. The fish immediately responded by rapid lateral movement; however, the crayfish floated to the bottom with a small bullhead clasped in the chelae and proceeded to eat it.

Discussion

Crayfish may play a much more active part in stream and lake ecology than has been attributed to them. The rapid removal of dead and incapacitated fish is illustrated by the foregoing observations; it was previously noted by Sayler (1933), who reported that even large trout were totally disposed of by crayfish (species not noted) in "less than 24 hours." The role of decapods in the clean-up of a salt marsh in Florida that had been treated with dieldrin was recently emphasized by Harrington and Bidlingmayer (1958), who noted that crabs ("portunids, xanthids, etc.") "set on the dying fishes" and that it was difficult for the investigators to outdo the crustaceans in the pickup of fish.

Whether or not the larger crayfishes could attack and overpower a large healthy fish is still open to question. It seems, however, that in areas where large crayfish are common, the pickup of fish after rotenone and shocking operations could be greatly influenced by predation as here described. Although losses of fish to reptiles, birds, and mammals have been noted in many publications dealing with rotenone operations, we have failed to find records of crayfish acting as a "loss factor." Depredations by crayfish may actually be more important than the more spectacular depredations by gulls, raccoons, and the like, because of the large populations found in some habitats and because of their benthic situation that puts them in prime position for predation on distressed fish.

The mechanisms that evoke attack behavior on the part of the crayfish may be linked with the visual perception of "unusual" behavior on the part of the prey. In aquaria, C. bartoni appear to pay little attention to fish that have been with them for some time, but move to attack any fish or other animal that is newly introduced into the tank. The possibility of olfactory or gustatory perception by crayfish of substances produced by injured or otherwise excited fish should, however, not be overruled (see Hasler 1957).

Acknowledgment

We thank Dr. Louis A. Krumholz for reading and criticizing this paper, and Mr. Charles Stone for taking the photographs in figure 1.

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SPAWNING CONTAINER MODIFIED FOR REMOVAL OF CHANNEL CATFISH FRY

At the Arkansas Game and Fish Commission's fish hatcheries, used 10-gallon milk cans have been exceptionally good spawning containers for channel catfish. However, removing the fry from the can is a problem. A 10-gallon milk can is too long to be laid into the conventional No. 2 square tub of water for gentle removal of the fry; instead, the container must be held up over the tub while the fry are poured into it. As the fry tend to adhere to the inside of the can, they must be washed out by splashing water up into it.

These fry habitually form a tight mass on the bottom of the can, always swimming downward, especially if disturbed. Fish-culturists at the Lake Hamilton Fish Hatchery took advantage of this habit when devising an easier, gentler means of removing the fry from the container.

A 1- by 4-inch slot has been cut at the bottom of the can (see photograph). To remove the fry, the modified container is lifted to the water surface, the slot being held at the top in order not to lose any fry. After about two-thirds of the water has been poured out, the container is set on edge in a tub about one-fourth full of water. After being rotated so that the slot is at the bottom, the container is slowly raised straight up from the tub. Because of their habit of swimming downward, the fry will swim out or can be gently forced out as the water drains out. The few remaining fry are washed out by raising and lowering the container in the tub of water.

The small round hole was originally cut into the can to let entrapped air escape. The slot, which is flush with the bottom of the can, was cut later to facilitate the removal of the channel catfish fry.

--CLINTON RICHARDS, Game and Fish Commission, Lake Hamilton, Arkansas.

FREE-LIVING ABILITY OF A WARM-WATER FISH PATHOGEN OF THE GENUS *AEROMONAS* AND FACTORS CONTRIBUTING TO ITS INFECTION OF THE GOLDEN SHINER

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THE BACTERIAL GENUS Aeromonas contains some important pathogens on warm-water fishes. In an earlier paper (1960) these authors attributed a heavy mortality of golden shiners (Notemigonus crysoleucas) during harvest to a bacterium of this genus. The present paper represents further study of the bacterium involved in this mortality. Of particular interest are a consideration of the source of aeromonal infection, an indication of the close relation between crowding of fish and the buildup of populations of Aeromonas, and the importance of injury to fish in bringing about infection.

Methods

To determine whether Aeromonas is a normal part of pond flora, bacteriological samples of both mud and water were taken from 4 farm ponds and 20 minnow-hatchery ponds in southern Illinois and 16 ponds of a Missouri minnow hatchery. For better understanding of seasonal changes in the aeromonal count, three sets of samples were taken from the Illinois hatchery ponds. All samples were plated on nutrient agar. The resulting colonies were identified by microscopic examination and by inoculation of shiners.

This study was financed by Southern Illinois University and Illinois Department of Conservation.

To demonstrate the free-living ability and the effect of the presence of organic pollution on the abundance of Aeromonas, a series of 1,500-milliliter sterile flasks that contained 1,000 milliliters of sterile water was prepared. These flasks were sealed and equipped with a filter to permit aeration without contamination. One such flask contained only sterile water; a second, sterile water and mud; a third, sterile water and an undamaged shiner; and a fourth, sterile water and a scarified shiner. Each of these flasks was inoculated with a pure culture of Aeromonas sufficient to give a final dilution of 2,000 to 3,000 organisms per milliliter. At a 24-hour interval, samples of water from each flask were taken and the number of organisms per milliliter was determined by plate count.

The effect of crowding fish upon the increase in population densities of Aeromonas was measured by making plate counts of samples of water from tanks holding different numbers of shiners. The tanks used were 24 feet long, 3 feet wide, and contained 12 inches of water.

To demonstrate what part mechanical damage plays in the development of aeromonal infections, a series of experiments involving the following procedures was conducted:

1. Shiners scratched, tumbled in a closed bucket, and placed in water containing an aeromonal inoculation ranging

from 500 to 1,500 organisms to the milliliter.

2. Fish damaged by removal of scales, tumbled in a closed bucket, and then placed in inoculated water as above.

3. Undamaged shiners placed in inoculated water.

All fish were checked at 12-hour intervals to determine development of symptoms and mortality. This series of experiments involved 20 different trials using 15 of the shiners in each.

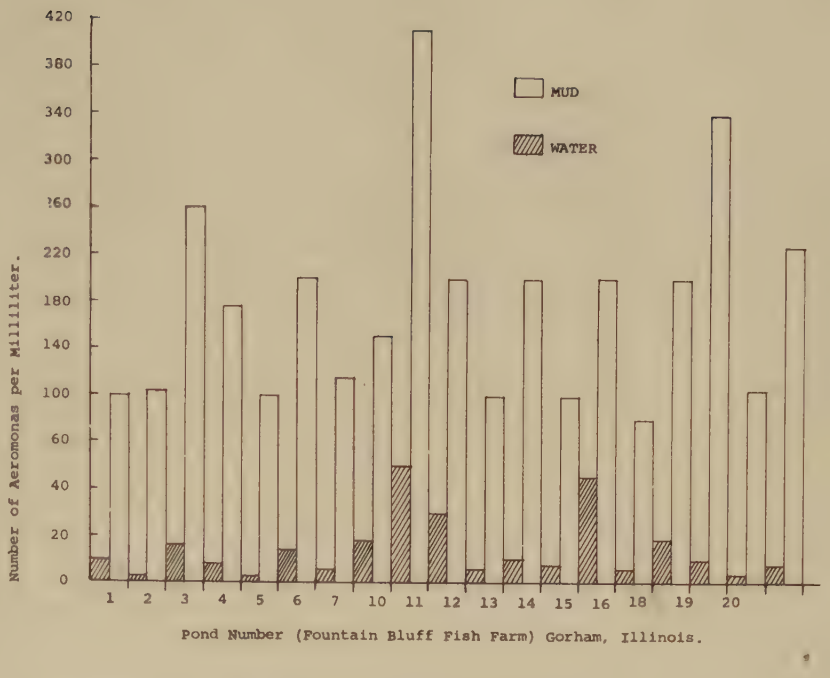

FIGURE 1.--Aeromonal count per milliliter in pond water and mud.

Results

Aeromonas was found in all of the ponds sampled. It appears to be a normal inhabitant of pond water and mud. This being the case, in hatchery management there is no value in avoiding pond-to-pond contamination so far as Aeromonas is concerned. In the southern Illinois hatchery ponds, samples were taken in winter, spring, and summer. Counts of aeromonal cells were similar in the three seasons. An average of the counts is given in figure 1. This shows that the organisms are more concentrated in the mud than in the water.

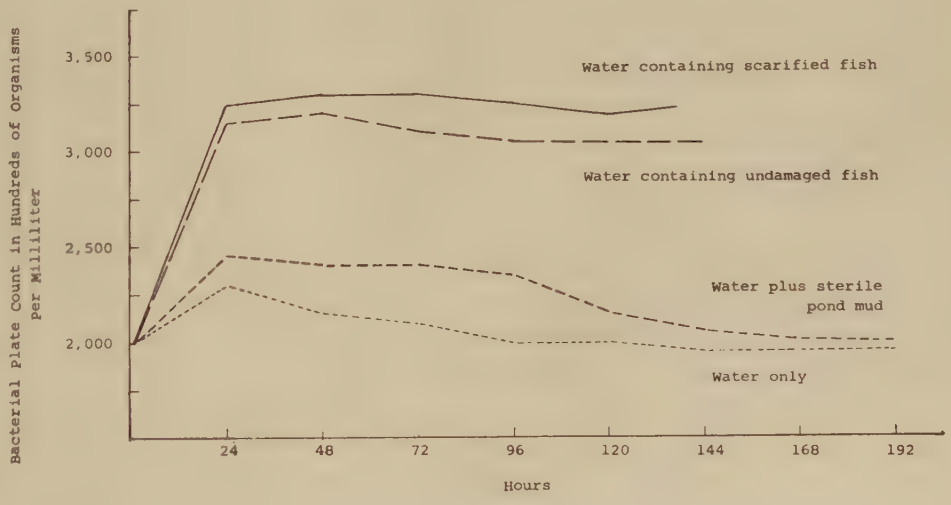

FIGURE 2.--Growth curves of Aeromonas in water only and water modified by the addition of mud, scarified fish, and normal fish. (Average of 10 trials, all at 22° F.)

The inoculation of a pure culture of the Aeromonas in plain water, in water plus sterile pond mud, in water containing an undamaged shiner, and in water containing a damaged shiner showed that the buildup of a population of Aeromonas is favored by at least certain types of

organic pollution (figure 2). This is especially true where fish constitute the source of pollution.

There is a direct relation between the numbers of the shiners in a holding tank and the number of aeromonal cells per milliliter (figure 3). Thus the aeromonal count for water containing 6,000 shiners averaged approximately twice the aeromonal count for the same volume of water containing 2,000 shiners.

Skin damage, as for example that which might be associated with harvesting, appears to increase greatly the chances of aeromonal infection. When shiners were scratched, tumbled in a closed bucket, and then placed in water containing 1,000 to 1,500 aeromonal cells, a 60-percent mortality attributed to aeromonal infection occurred in 12 hours. In a group of fish that had been damaged by removal of several scales and then shaken in a closed bucket, the mortality due to Aeromonas was 40 percent. In both of these experiments the loss of fish among the controls, i.e., undamaged fish placed in water inoculated with Aeromonas, was less than 1 percent.

Shiners that were damaged as above and placed in water containing less than 1,000 aeromonal cells per milliliter did not suffer high mortality.

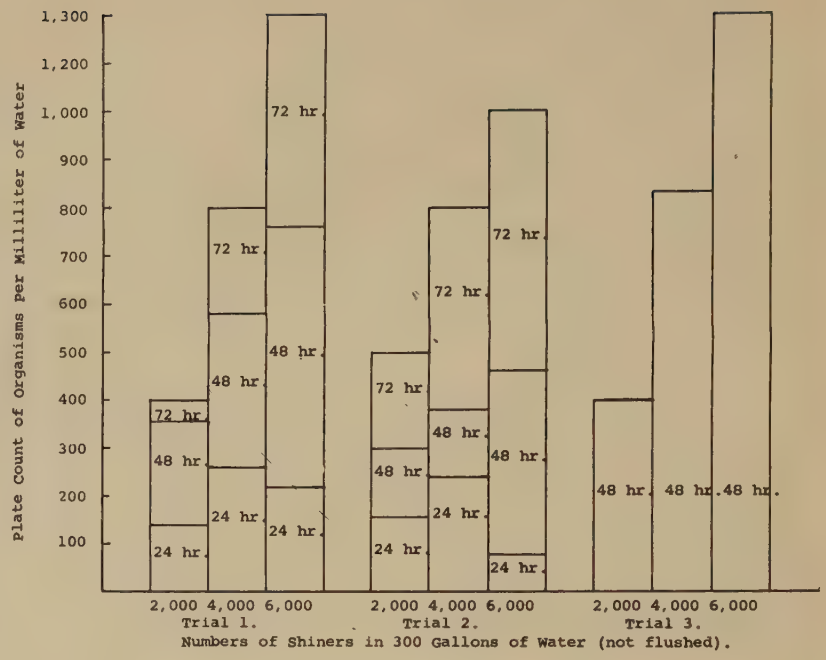

FIGURE 3.--Relation between numbers of shiners per unit volume of water and the count of Aeromonas.

Conclusions

1. The aeromonal fish pathogen considered here can exist in the free-living state in both pond water and mud. It may be universally present in the waters of the southern Illinois region.

2. There appears to be little need of avoiding pond-to-pond contamination.

3. Dense aeromonal populations are favored by the presence of fish.

4. In the golden shiner, infection by Aeromonas is closely associated with mechanical damage.

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Non-English-speaking fishermen of foreign descent must be credited with naming many American fishes, such as barracuda, cero, grouper, pompano (Spanish); bocaccio (Italian); and capelin and inconnu (French).

THE USE OF BENZENE HEXACHLORIDE AS A COPEPODICIDE AND SOME OBSERVATIONS ON LERNAEAN PARASITES IN TROUT REARING UNITS

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THE PAGE SPRINGS REARING STATION, on Oak Creek, 12 miles southwest of Sedona, Arizona, has recently been plagued with a parasitic copepod referable to Lernaea cyprinacea (Linn.) or L. carassii Tidd. It was first discovered in May 1957 and was identified at that time. The infestation grew in magnitude until all rearing units were affected. The rainbow trout (Salmo gairdneri) losses increased progressively over a period of 2 years. At this point an intensive control program became mandatory to insure future use of the station as a trout producer.

This report describes the use of benzene hexachloride as a chemical control that was economically feasible for large-scale application and the effects it produced on Lernaea as well as on rainbow trout. Also included are some observations on the life history of the parasites in the trout rearing ponds and a description of the disorders which they caused.

It has been speculated that the copepods were originally introduced to the station on infected largemouth bass (Micropterus salmoides). A short time after being identified at the station, the parasites were also found on centrarchids in several large Arizona impoundments. Fish from these impoundments had been transported in tanks which later were used in transporting trout about the station. It appears that the avenue for the introduction of the copepod was well paved by failure to sterilize the tanks thus exposed.

During the first few months after the infestation was noted, several chemical controls were applied rather spasmodically. Formalin was among those that received the greatest amount of attention. At a concentration of 1:4,000, formalin was applied for an hour to the dirt rearing ponds containing parasitized trout. The trout were weak because of heavy infestation of parasites, and it was evident that any treatment would be hazardous. The results of the formalin treatment were encouraging with regard to its effect on copepods. However, because of the strong concentration needed to obtain results and the tremendous costs involved in treating 31 rearing units, the use of formalin was deemed impractical. Also, it was evident that the hour exposure period necessary to obtain results was prohibitive because of the weakened condition of the parasitized trout.

Description and Life History

The copepod Lernaea was found primarily on rainbow trout, attached to the gills, fins, and other body surfaces. Its anterior end was composed of four cephalothoracic horns embedded very firmly in the flesh. Posteriorly, the fully developed females housed a pair of long egg sacs in which the young developed. Eggs in the external egg sacs appeared light green, and those in the ovary appeared black. Size of the parasites ranged from 7.5 to

22.5 millimeters, including the egg sacs. Their color varied from light green to dark brown.

According to Wilson (1918), the young break from the egg sac and are free-swimming for a time. They attack the host late in the course of the six copepodid stages. As metamorposis takes place, the copepods mature and mating occurs. Soon after, the males drop off and die; the females, however, remain attached and undergo further development. The eggs then hatch, and the females begin to degenerate and eventually die.

Observations on Copepods

The Lernaea observed during this study consisted only of maturing females attached to the host. Hundreds of plankton hauls and gill examinations were made in an effort to isolate the males for examination, but this search failed to produce either a male or a free-swimming copepodid.

Female copepods were examined weekly to observe changes in the development of eggs during a period of rising water temperatures. Four different stages of development were noted: the females contained (1) no eggs, (2) eggs in the ovaries only, (3) eggs in the egg sacs only, and (4) eggs in both the ovary and the egg sac.

Table 1 reveals the monthly egg status of the maturing females. As indicated in the table, 63 percent of the specimens examined during March 1959 lacked eggs in the ovaries and egg sacs, while 37 percent contained eggs in some part of the body. During April and May, however, the occurrence of maturing females with eggs increased to 67.3 and 91.1 percent, respectively. During June, only parasites containing eggs, either in the ovaries or in the egg sacs, were present. Further observation was curtailed because it was recommended at this time that all parasitized trout be removed and transferred to a large holding unit. It is believed that this removal to the isolation pond (which is fed by a large volume of water) prevented the copepods from producing any young. Apparently the strong current through this unit adversely affected the success of any possible hatch.

Detection of Copepods and Preferred Location of Attachments

In the fall and winter of 1958; the trout were lightly parasitized. Periodic examination revealed only a very few copepods attached to fish. For example, an examination of 300 trout from one rearing unit on November 5, 1958, indicated that they were free of parasites, as not a single copepod was found. On March 11, 1959, the pond population was sampled again. At this time the trout were found to be harboring considerable numbers of maturing females. It is now believed that no parasites were detected in November 1958 because they were completely embedded in the body tissues of the fish at that time. Gradually the parasites began to extend the posterior portion of their bodies through the trout tissues. This became apparent in March 1959, when microscopic examination revealed minute portions of the bodies protruding. As development progressed, the parasites became very apparent and were easily detected by the unaided eye.

From March through June 1959, data were collected on the locations of lernaeid attachment. The number of adult and maturing females present was recorded for each particular body area. The copepods were embedded to some degree on all external body surfaces but seemed to prefer locations which offered the greatest degree of protection from water currents (table 2).

Density of Copepods Per Trout

To determine any changes in the density of parasites, eight rearing units were surveyed twice monthly over a 4-month period. Trout were caught at random from each of the eight ponds by chumming them close enough to the shore to be captured with a dip net. Fish so caught were placed in holding cans and transferred to the laboratory for examination. Each trout was scrutinized to determine the

TABLE 1.--Stages of copepod egg development during March, April, May, and June in relation to surface water temperature for each month

	Parasites present Number	Percent	Parasites present Number	Percent	Parasites present Number	Percent	Parasites present Number	Percent
	March 58° F.[1]		April 33° F.[1]		May 69° F.[1]		June 73° F.[1]	
With no eggs present	58	63.0	32	32.7	22	8.9	0	0
With eggs in ovaries	14	15.2	24	24.5	100	40.3	20	52.6
With eggs in egg sacs	4	4.4	10	10.2	10	4.0	4	10.5
With eggs in both ovaries and egg sac	16	17.4	32	32.7	116	46.8	14	36.8
Total	92	100.0	98	100.0	248	100.0	38	100.0
Summary:								
No eggs present	--	63.0	--	32.7	---	8.9	--	0
Eggs present in some region	--	37.0	--	67.3	---	91.1	--	100.0

[1] Average water temperature.

TABLE 2.--Locations of parasitic copepod attachments

Location of attachment	Number present	Percent per area
Gill arch	122	24.8
Opercle and pre-opercle	90	18.3
Behind dorsal fin	72	14.6
Behind pectoral fin	72	14.6
Behind ventral fin	42	8.5
Buccal cavity	26	5.3
Mandible	16	3.3
Side of body	16	3.3
Behind adipose fin	12	2.4
Eye	10	2.0
Maxillary	6	1.2
Behind anal fin	4	.8
Caudal fin	4	.8
Total	492	100.0

number of the parasites present. Attention was also given to lesions or scars regarded as evidence of previous infection.

The number of parasites per fish for a particular month, divided by the number of individual fish examined, is referred to as the parasite frequency index (table 3). This index does not include the presence of lesions from previous infections.

The most heavily infected trout were yearlings. These fish were from 4.8 to 13.3 inches in length; their average length was 9.8 inches. The Lernaea seemed to prefer yearling trout as hosts, as trout smaller than 4.8 inches were not found to be infected.

Secondary Infection After Parasitism

The parasites attached to trout injured them to some extent by sucking large quantities of blood, but mechanical injury to the tissues and gill filaments was the predominant cause of the heavy trout mortalities. The tissues near the site of copepod attachment usually appeared hemorrhagic. On some trout the area around the lesion and the parasite itself were heavily coated with fungus.

On most trout the gill filaments and lamellae were severely affected by the presence of a copepod. Affected lamellae were usually bent and twisted into distorted positions. Examination with the microscope revealed pronounced swelling of epithelium on the lamellae and characteristic haycock-like masses of bacteria on the distal portion of the lamellae. These bacteria were determined to be Chondrococcus columnaris. In advanced stages the C. columnaris had completely destroyed the lamellae. The operculum of the trout was also the target of this bacterial action, and in extreme cases the entire gill cover had disappeared.

Water temperatures in the rearing ponds increased from 63° F. at the middle of April to the seventies early in May. As C. columnaris thrives above 65° F., this was an ideal situation for the invasion of gills already injured by the presence of copepods.

Treatments with copper sulfate were of little benefit to trout suffering from gill hyperplasia. Heavy mortalities occurred during the latter part of May and the first of June. Losses ran as high as 500 pounds daily. All chemical treatments were abandoned during June, because the trout were too weak to stand the strain imposed by chemical application.

It is believed that a combination of factors contributed to the tremendous losses.

TABLE 3.--Density of parasites per fish during March, April, May, and June, 1959

Month	Number of fish	Number of parasites	Parasite-frequency index
March	80	110	1.4
April	32	70	2.2
May	30	256	8.5
June	4	38	9.5
Total or average	146	474	3.2

First, the parasites were responsible for the irritation on the gills, thus providing a foothold for invading bacterial infections. Second, the rearing ponds were deep, and the limited water supply could be expected to provide a complete turnover of the pond waters only after approximately 8 days. With such a slow pond turnover, accumulated metabolic waste matter and warm water certainly prevailed, thus providing a polluted environment. In an environment of this kind, the gills may have received a chemical irritant derived from the metabolic wastes, with the result that stress on the already-strained respiratory functions was increased.

Benzene Hexachloride Treatments

Parasitic copepods, once established in rearing units, are a continual source of irritation to trout. A chemical treatment that would be economically feasible, that would destroy copepods yet not harm the host, would be highly advantageous. In a search for such a chemical, experiments with a powdered lindane consisting of 75 percent benzene hexachloride and 25 percent inert material were begun in March.

The first experiment was conducted in a raceway containing parasitized trout. The water temperature was 68° F. The lindane at a concentration of 1:10,000,000 was sprayed over the water and held for a 1-hour exposure period during which more water was not allowed to enter the raceway. Under these conditions the lindane was found to be toxic to trout, as the results indicated a loss of 7 percent. The trout surviving such treatment refused feed over a 24-hour period.

Lindane was next tested at a concentration of 1:10,000,000 applied by dripping it into the raceway with a continuous supply of water. The mortalities resulting from this type of treatment were insignificant, and the fish took feed continuously during the exposure period.

The treatments applied to the large rearing units were made in a similar manner. The lindane was weighed and placed in a container to which water was added to form a paste. An emulsifier was necessary to keep the chemical in suspension during the prolonged drip period, because lindane mixed with water alone settles quickly to the bottom. The emulsifier, a spreader activator used commonly with various agricultural chemicals, was added to the lindane at a ratio of 5 ounces of activator to each ounce of lindane. After the addition of the emulsifying agent, the lindane mixture was placed in a barrel containing 25 gallons of water and mixed thoroughly. A barrel was placed directly over each incoming water supply. At the bottom of each barrel there was a faucet for releasing the lindane mixture directly into the incoming water. Faucets were adjusted to apply the lindane at a fast drip. The application usually required 72 to 96 hours. A period of 3 days was allowed between treatments to insure against a chemical buildup in the rearing units.

When the lindane was applied at too fast a rate, the trout skimmed the surface at accelerated speeds and became very erratic, even swimming into obstacles and ramming into the banks with such force as to become stranded. Generally trout are able to survive a short period of over-treatment, but in all cases the chemical applications should be halted immediately when the first signs of nervous behavior are observed.

The application of lindane to ponds while water is flowing through them in the usual manner presents many difficulties. It is almost impossible to insure that all trout will be exposed to the proper chemical concentration for any required length of time.

Effects of Lindane on Copepods

Lindane was applied on a schedule over a 4-month period. During this period copepods were examined every 2 weeks to determine whether they were dead or alive. Trout were caught with dip nets and transported to the laboratory alive. The copepods were removed from the host by means of a sharp-pointed narrow knife blade. The blade was forced into the connective tissue as close to the parasite

as possible without injuring it. The point of the blade was pushed below the head of the parasite and very gently used as a prying instrument. By this means, the parasites were removed quickly and without harm. The specimens removed were immediately put under a microscope for examination. Parasites were considered alive when a rhythmical movement of body fluids in the abdominal region was noted; those showing no movement of body fluids were considered dead. Dead parasites normally remained attached to fish for several weeks before finally deteriorating and becoming completely detached.

The percentages of dead and live parasites over the 4-month period of treatments are shown in table 4. At the end of March 1959, the first month of intensive treatment, 33.7 percent of the parasites examined were dead. In April and May, only small increases in the percentages of dead parasites were observed. A quite significant increase was observed in June, when more than half of all the copepods still attached to the host had died.

On the basis of these data, it is evident that copepods exposed to lindane in a concentration of 1:10,000,000 were difficult to control because of the resistant chitinous membrane surrounding the vital organs, but continuous exposure over a 4-month period resulted in significant increases in the number controlled.

It should be pointed out that during June only adult females with eggs were observed. As the females do not normally die until the eggs have hatched, this would seem to substantiate the hypothesis that parasite mortalities were being caused by the deleterious effects of the lindane.

Sterilization of Ponds and Raceways To Eradicate Parasitic Copepods

It was impossible to eradicate copepods by means of treatments while the parasites were attached to the trout. It was decided, therefore, that all parasitized trout should be removed from the infected rearing units and put in an isolation unit. With all infected fish isolated, sterilization measures directed at complete elimination of the copepods could be employed.

Lindane, because of its efficiency in killing copepods and its low cost, was used in the hatchery sterilization. The lindane used in this work was in liquid form. Its active ingredients were 23.5 percent gamma isomers of benzene hexachloride and 29.0 percent aromatic petroleum derivatives; inert ingredients amounted to 47.5 percent. The liquid was believed to have an advantage over the 75-percent powder form for this work because of the added killing power derived from the aromatic petroleum.

Before being sprayed, all ponds were completely drained. Strong solutions of lindane were then poured into the spring water supply of the ponds and allowed to pass through all ditches and pipes feeding into the ponds. The ponds were then filled with this water to a depth of 1 foot before the water supply was shut off.

The lindane was mixed with water at a concentration of 1 gallon of lindane to 50 gallons of water and put in a 100-gallon

TABLE 4.--Parasites dead or alive during March, April, May, and June, 1959

	Parasites		Parasites		Parasites		Parasites	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	March		April		May		June	
Alive--------	61	66.3	64	65.3	157	63.3	17	44.7
Dead---------	31	33.7	34	34.7	91	36.7	21	55.3
Total-----	92	100.0	98	100.0	248	100.0	38	100.0

mobile spray unit. The effective concentration in pond sterilization was 5 p.p.m. Each unit received the specified concentration for the surface area involved.

Every square foot of water surface, all pond sides above the water level, and all inlets and outlets were sprayed. Ponds were then allowed to set for 3 weeks.

All aquatic insects and plankton died in 1 hour after the spraying. The presence of millions of chironomid worms on the surface indicated the ability of lindane to penetrate bottom mud and kill organisms in it. This concentration was toxic even to bullfrogs. Reactions of the frogs were visible after 30 to 60 minutes of exposure. They became excited, swam rapidly at the surface, and had muscular spasms resulting in short, jerky movements; then they lost equilibrium and swam on their backs. Death came after varying periods, sometimes as long as 24 hours.

After removal of all parasitized trout from the isolation unit, treatment of the 76 raceways just above it was begun. Strong concentrations of lindane were sprayed over all cement surfaces and gravel bottoms; strong solutions were applied to the spring, ditches, and feeder pipes throughout the system. Then the isolation pond was treated. Lindane was applied to all buckets, pans, tubes, screens, seines, and equipment that had been in contact with infected water. Tanks used to transport parasitized fish were sterilized thoroughly.

Results of Hatchery Sterilization

After a 2-month period for the drying of pond bottoms, all rearing units formerly harboring copepods were restocked with fingerling rainbow trout. Thereafter trout from these units were examined weekly. Plankton samples were taken periodically to discover whether Lernaea existed in the free-swimming copepodid stages.

One year after the complete hatchery sterilization, no signs or symptoms of the parasites could be found.

Summary

1. Over a 2-year period, progressively increasing losses of rainbow trout were caused by an infestation of parasitic copepods, referable to Lernaea cyprinacea (Linn.) or L. carassii Tidd.

2. During a study of maturing females attached to the host, percentages of those with eggs in ovaries or egg sacs (or both) rose progressively as water temperatures rose from March through June.

3. The density of parasites per trout ranged from 1.4 in March to 9.5 in June.

4. Gill filaments and lamellae were severely affected by the copepods and became the target of bacterial gill disease.

5. Benzene hexachloride was applied to parasite-infected ponds by dripping lindane at a concentration of 1:10,000,000 into the incoming water, usually for 72 to 96 hours.

6. After 4 months of intensive lindane treatments, 55 percent of the adult female copepods had died.

7. At a concentration of 5 p.p.m., lindane was effective in the sterilization of infested rearing units.

8. A year after the complete hatchery sterilization, no signs or symptoms of the parasites could be found.

9. Use of lindane to eradicate parasitic copepods from ponds and raceways can be considered from two important angles: (1) It is economically feasible for large-scale work; (2) it is capable of penetrating copepod environments to such a degree as to destroy all stages of the life cycle.

Acknowledgments

The author wishes to express appreciation for the encouragement, aid, and suggestions given throughout this work by Burrell Russell, superintendent of Page Springs Rearing Station. Special thanks are due Dr. Gerald A. Cole, associate professor of biology at Arizona State University, who critically read the manu- and gave invaluable assistance in the study.

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TOXIC EFFECTS OF ERYTHROMYCIN THIOCYANATE ON RAINBOW TROUT

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KIDNEY DISEASE resulting from infection with Corynebacterium was diagnosed, in February 1960, in 2-, 3-, and 4-year-old rainbow trout (Salmo gairdneri) brood stock held at the National Fish Hatchery, Manchester, Iowa. The rate of mortality was not high, and it was hoped that prompt treatment would prevent an epidemic.

In tests conducted with brook trout (Salvelinus fontinalis) at the Eastern Fish Disease Laboratory, Kearneysville, West Virginia, erythromycin was the most effective antibiotic for treatment of the disease. Accordingly, erythromycin thiocyanate, a formulation of the antibiotic used for poultry, was fed at Manchester at the rate of 4.5 grams of drug per 100 pounds of fish per day for a 21-day period. The antibiotic was incorporated into the diet, which consisted of 50 percent meat and 50 percent dry meal. The diet was fed to approximately 11,000 pounds of rainbow trout at the rate of 1 percent of body weight.

On the sixth day the fish decreased feeding and showed extreme nervousness. By the ninth day they had almost ceased feeding and were choking violently. This condition progressed through the treatment period until the trout would go into spasms and convulsive gasping when excited by the presence of someone walking along the raceway, and then--exhausted--would sink to the bottom for several seconds or even a minute before righting themselves and swimming away. Twice during the treatment feeding was stopped for a day or two, with the result that the fish regained their appetites, but the toxic reactions continued.

At the end of the 21-day period the fish were put on the regular hatchery diet (dry meal pellets on 5 days a week, meat feeding on 2 days). They appeared to improve after the third day on this diet and were feeding and acting normally by the tenth.

It was not possible to determine the number of mortalities due to feeding the erythromycin thiocyanate, as fish were also dying from kidney disease. The mortality increased slightly (less than 1 percent) in several raceways and could have been caused by the drug.

Posttreatment examination of the fish showed many with inflamed ovaries and pustules on the liver and kidney. This condition was not observed in pretreatment examinations. Specimens of these organs, preserved in 10 percent formalin, were sent to the Eastern Fish Disease Laboratory at Kearneysville, West Virginia, for histological examination. The laboratory report included the following information on the specimens:

> The ovaries appeared fairly normal when compared to normal sections on file in this laboratory. The kidney tubules showed some damage. According to Wood and Yasutake (1955), the pathological change most frequently seen in sulfa drug and antibiotic therapy is abnormal deposition of hemoglobin in the kidney tubules and hematopoietic tissue. Stains specific for hemoglobin were used to stain the kidney specimen and showed several areas where hemoglobin was abnormally deposited.

No pathological change due to erythromycin was reported on the liver specimen.

The treatment of the kidney disease in the brood-stock trout was considered successful. Smears were made of the kidneys of all the fish which died during the 3-month period. Examination of these smears has not revealed evidence of kidney disease. Periodic examination of this group of trout will be continued, however, to determine whether the early treatment of the disease effected a complete cure.

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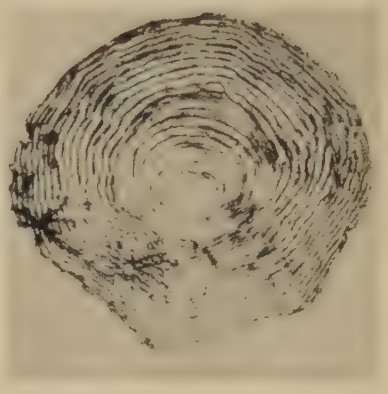
FORMATION OF AN ACCESSORY ANNULUS ON THE SCALES OF STARVED WHITEFISH

In northern latitudes wild fishes that hatch in spring and summer normally complete the first annulus on their scales before the end of the next spring. Species hatching late in the fall usually form no annulus in the first winter. Artificially and naturally propagated fish of the same species usually develop an annulus in the same season unless the environment is altered.

Early in May 1948 the Ontario Fish and Wildlife Division sent about 50,000 Lake Erie whitefish fry to Wheatley, where they were put in a concrete holding tank about 80 feet long, 40 feet wide, and 8 feet deep, with a center partition a little lower than the sides. Lake Erie water was piped to the bottom of the tank. The objective was to determine the feasibility of rearing fish to the fingerling stage on natural feeds.

On June 29, two fish dip-netted from the tank were 1.63 and 1.94 inches long. Some of the fish had fungus around the gills, but there was no serious mortality. About July 28, heavy losses occurred. Survivors were fed finely ground calves' liver, and soon many began to recuperate and grow again.

Eleven survivors sent to the laboratory on September 22 had total lengths ranging from 64 to 120 millimeters (2.52 to 4.72 inches) and averaging 80.1 millimeters (3.19 inches). The scales of two (65 and 89 millimeters) gave no sign of starvation. Three (64, 80, and 82 millimeters) had a rather slight accessory annulus formed by the crowded or incompleted circuli. Two (74 and 80 millimeters) had a fairly good annulus. The other four (67, 80, 80, and 120 millimeters) had a typical annulus inside the marginal circuli. Computation indicated that the false annulus of the 120-millimeter fish (see photograph) had been completed when the fish was about 56 millimeters long.



Lake Erie whitefish--age group 0; one accessory annulus; total length, 120 millimeters--reared in a concrete tank at Wheatley, Ontario. 9/22/48.

(Photograph by Clifford Tetzloff)

This indicates that if fish--introduced or hatched in natural waters--had starved and developed a distinct annulus within a series of circuli during the growing season, the erroneous age could not always be recognized. Apparently the aging of fish taken from natural waters--especially among fish deposited by hatcheries in midsummer--can be subject to error.

--JOHN VAN OOSTEN, Bureau of Commercial Fisheries, Ann Arbor, Michigan.

A POSSIBLE CONTROL OF FURUNCULOSIS

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FURUNCULOSIS has caused severe mortalities in trout hatcheries since the first units were established. The causative organism has been isolated and cultured. Treatments have been devised to arrest the disease--even temporarily to cure it--but it often recurs. There are hatcheries that never have had an attack of furunculosis, whereas there are others that are constantly plagued by outbreaks of the disease.

The present treatments with sulfa or the "miracle drugs" mixed in the diet often arrest the infection. Sometimes the amount of the drug used in the diet is excessive, owing to inaccurate estimates of the weight of fish in the group being treated--and, as a result, shock occurs, causing mortalities to mount.

By studying charts of hatchery management, one finds that the disease occurs under certain hatchery conditions. The most severe outbreaks are in the summer, when high temperatures are encountered. However, outbreaks often occur when the fish are handled excessively. Inventories, grading, shipping, overcrowding, and spawn-taking seem to be associated with the infections.

The trout hatcheries that have the most trouble are those which have hard water with associated algae problems and fluctuating temperatures. It is evident from hatchery data that this disease occurs after changes in water quality and rearing management.

A very important factor that hatchery management charts do not cover is the oxygen content of the water. Analyses of most hatchery water supplies have been made from time to time. However, these analyses have been made, as a rule, during the daylight period in a manner similar to the making of readings in lakes and streams. Readings made at the break of day generally are much lower. In situations where algae are present, the available oxygen reaches the saturation point in the afternoon but is dangerously low at the break of day. As temperatures rise above 50° F., the amount of available oxygen decreases. However, the trout will eat more during the period of higher temperature, and therefore their oxygen requirement will be greater. The handling of fish, for one reason or another, at times when the available oxygen content is low can easily result in an additional requirement by the fish and consequently in a critical situation.

A number of years ago the attacks of furunculosis at one New York State hatchery were so severe that serious consideration was given to discontinuing operation of the unit. However, in a final effort to improve the efficiency of the hatchery, a fountain was installed to aerate the water supply. The success of trout rearing was enormously increased, although outbreaks of furunculosis occurred from time to time. In later years the head screens used in ponds were replaced by "jump screens." The purpose of installing this type of screen was to prevent the injuries that occurred when fingerling trout hit the conventional galvanized hardware-cloth screen. The "jump screen," a small wooden-slat arrangement that rests on

the dam boards in a horizontal position, also increases aeration greatly. At the present time the production at this hatchery is double the production that was previously possible. Furunculosis appears at times but is easily controlled.

In another hatchery, epidemics of furunculosis caused serious losses for a number of years during the summer months. The amount of available oxygen in the water fluctuated greatly in accordance with the weather conditions and time. "Jump screens" were installed 2 years ago, and outbreaks of furunculosis have not caused trouble in the past 2 years.

In 1958 one of the hatchery rearing units was remodeled. The old rearing-trough battery was replaced with concrete raceways. Since these new raceways have been in operation, furunculosis has constantly plagued the hatchery during the summer months. Sulfa treatments have not controlled the infection. The oxygen analyses that are available are good, but all have been made in the afternoon. This past fall it was learned that the spring reservoir used by the hatchery maintains a luxuriant growth of algae all summer. This fact, coupled with experiences at other hatcheries, leads to the theory that low available oxygen in the early morning during certain periods may be closely associated with outbreaks of furunculosis. During the summer of 1961, experiments will be conducted to substantiate the theory or prove it in error.

There is strong reason to suspect that low available oxygen may often be a critical stress factor favoring development of furunculosis. Proper aeration at the intake and between ponds can correct low oxygen conditions in most waters. Feeding pollution, dirty ponds, or other factors that make an added demand on the available oxygen should be avoided. It is believed that a minimum oxygen reading should not be less than 5.5 or 6 p.p.m. Indications are that maintenance of such oxygen levels will serve greatly to reduce the incidence of furunculosis.

COMPARISON OF JAW, CHEEK, DART, AND SPAGHETTI TAGS

To compare the effects of lower jaw, spaghetti, cheek, and dart tags on survival, growth, and rates of loss, 4 lots of rainbow (and a few brown) trout containing 23 of each of these marks were held with 23 adipose-fin-clipped fish as controls in separate hatchery batteries for 4 months.

For ease and speed of correct application, the tags were ranked as follows: jaw, cheek, dart, and spaghetti.

Ninety-six percent of the fish survived, with no significant differences in survival for the five marks or the four batteries.

Losses of jaw, cheek, and dart tags were significant as compared to losses of the spaghetti tag and adipose-fin clip. The great losses of cheek and dart tags indicated that they were of little use for these species and sizes of fish.

Total lengths of the fish were from 6.2 to 13.5 inches at the start, 8.0 to 17.0 at the end. The smaller of two size groups made a mean increase of 3.7 inches in length; the larger, 2.6. Mean increases in length of the smaller fish were significantly less with jaw and cheek tags than with the adipose-fin clip and spaghetti tag. Larger fish so marked had no significant differences in mean increases in length.

The rates of recovery of the variously tagged fish by fishermen were not significantly different in this study.

--WESLEY C. NELSON, Department of Game and Fish, Denver, Colorado.

For details, see Mr. Nelson's report entitled "A Comparison of the Losses of Jaw, Cheek, Dart, and Spaghetti Tags and Their Effects on the Survival and Growth of Trout Under Hatchery Conditions," obtainable from the Denver office of the Colorado Department of Game and Fish.--The EDITORS.

THE USE OF MERTHIOLATE ON GREEN EGGS OF THE CHINOOK SALMON

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MERTHIOLATE has been used as a disinfecting agent for green and eyed eggs of various species (Gee and Sarles 1942, Snieszko and Friddle 1948). The present report is a description of the effects of the chemical on green eggs of the chinook salmon (Oncorhynchus tshawytscha).

The need for this study was indicated when a program of transporting green chinook eggs from various sources to the Coleman National Fish Hatchery at Anderson, California, was required as part of a disease study. There was no available information to indicate whether the salmon eggs would withstand the disinfecting routine shown by Snieszko and Friddle (1948) to be tolerated by trout eggs, or whether the fry and fingerlings from salmon eggs so treated would suffer high mortalities or be abnormal in appearance or activity.

Materials and Methods

Three groups of green chinook salmon eggs were obtained from the Spring Creek National Fish Hatchery at Underwood, Washington. Of the 115,360 eggs used in the experiment, 62,445 were treated with merthiolate and 52,915 were untreated. The first, or pilot, group of 5,119 eggs held at the Willard Fish-Cultural Hatchery was divided into two parts, 1,594 treated eggs and 3,525 untreated. The second group, also held at this hatchery, had a total of 58,619 eggs, of which 22,931 were treated and 35,688 were untreated. The third group, transferred to the Coleman National Fish Hatchery, had 51,622 eggs, of which 37,920 were treated and 13,702 were untreated. Groups 2 and 3 were compounded from one group of eggs, some being treated and some untreated. As they were, in essence, the same group, the lot held at Willard was an effective, representative control for the eggs shipped to Coleman.

The method for treating the eggs was the merthiolate-dip technique described by Snieszko and Friddle (1948) and modified as follows:

A 1:5,000 solution of merthiolate was made and put into "shot-gun" egg-handling cans (19 inches deep, 8 inches in diameter). Newly spawned, water-hardened eggs--a minimum of 1 hour and a maximum of 3 hours were allowed for water hardening--were gently poured into the cans to a depth of two-thirds of the height of the can, while the excess of merthiolate solution was allowed to run over the top. The eggs remained in the solution for 10 minutes, during which time they were gently stirred by hand every 3 minutes. At the end of the prescribed time, a burlap cover was put over the open end of the can and the merthiolate solution was poured off the eggs. These were then poured into a can of fresh, clean water and gently stirred for 2 minutes to be thoroughly rinsed. This rinsing was repeated three times, and then the eggs were transferred to suitable containers for transportation to the designated hatching station. The untreated eggs were handled in the same way except that water was used instead of the merthiolate solution.

The first group of eggs was transported to the Willard National Fish Hatchery, a distance of 18 miles, in two 1-gallon thermos jugs. The second group was also transported to the Willard station, this time in the "shot-gun" cans, to serve as a control on the third group, which was moved to the Coleman station. The group moved to Coleman was first packed by the "dry" method as follows: The treated eggs were divided into a series of lots consisting of approximately 10,000 eggs each. Each lot was wrapped in burlap that had been completely wetted down in a hatchery trough. The wrapped lots were placed, one lot per tray, in metal carrying trays (6 inches deep and 11 inches in diameter) of a 6-tray metal shipping container that had been chilled overnight in the hatchery cold room. The untreated eggs were all wrapped together and placed in one tray. These eggs were put aboard an airplane 5.5 hours after they were spawned.

Data in this report were obtained from observations of the eggs from the time of spawning until 1 month after they started feeding, after which they were used for other experimental purposes.

Results

The table is a composite of data obtained from four developmental stages of the three lots of eggs used in this experiment. As is readily observed, lots 1 and 2 are similar in pattern, whereas lot 3 differs markedly. For this reason, the first two lots will be discussed together and the third will be treated separately.

After treatment, lots 1 and 2 were transported, in water, the relatively short distance of 18 miles to the Willard station and were then put in troughs. Thereafter they received the routine handling given all eggs at the station. The results, as reflected by the percentages, were in keeping with the usual losses sustained by eggs, fry, and fingerlings of the Spring Creek stock of chinook salmon at the Willard station (nonexperimental fish). Any slightly higher losses could be attributed to the handling that they received in the treatment.

Lot 3, transported to Coleman by truck and airplane, was delayed en route for 14 hours and was put in water at a temperature higher than the temperatures during spawning and transportation. In spite of this, the initial losses were only 21.0 percent of the treated eggs and 19.6 percent of the untreated. The losses sustained in each succeeding developmental stage decreased considerably until the losses recorded in the fingerling stage (2.8 percent for both groups) were not much greater than those suffered in lots 1 and 2.

Percentage losses in all but lot 3 compared favorably with those of the hatchery production (not part of the experiment). The production group received no special handling, just that necessary for transport from Spring Creek to Willard.

Discussion

Disinfecting the green eggs of various fishes has been a time-honored, and to a certain extent effective, method of control for diseases known to be, or suspected of being, transported on the eggs. When an experimental program required the transportation of chinook eggs from one watershed to another, it was felt that such a disinfecting treatment should be given the eggs as a routine safeguard against the spread of unspecified disease(s). There were no available reports indicating that merthiolate had been used on green chinook eggs, so the present study was made to establish the effects of such a regime.

Three lots of eggs were used: the first was a pilot study, and the last two were parts of the larger experimental program. After the feasibility of the treatment was established by lot 1, lots 2 and 3 were set up by dividing a large number of eggs into two groups on a random basis. Lot 2 served as a double control for lot 3--first as a control for the transporting of lot 3, later as a control for this group within the framework of the main disease study.

The first two lots were handled in a similar manner, transported the same distance, and placed in the same hatchery, where they were treated in the routine manner by the same personnel. Lot 3,

DATA OBTAINED FROM FOUR DEVELOPMENTAL STAGES OF THREE LOTS OF SPRING CREEK NATIONAL FISH HATCHERY CHINOOK SALMON EGGS USED IN THE MERTHIOLATE TREATMENT STUDY

Stage		Lot 1		Lot 2		Lot 3		Non-experimental fish at Willard
		Treated	Untreated	Treated	Untreated	Treated	Untreated	
Green eggs--	Original number of eggs per lot	1,594	3,525	22,931	35,688	37,920	13,702	----
	Green egg mortality	167	443	2,399	5,533	8,227	2,685	----
	Percentage of mortality	10.5	12.6	10.5	15.5	[1]/ 21.0	[1]/ 19.6	11.4
	Accumulative percentage of mortality	10.5	12.6	10.5	15.5	21.0	19.6	11.4
Eyed eggs---	Number of eggs	1,427	3,082	20,532	30,155	29,693	11,017	----
	Eyed egg mortality	20	50	485	640	3,180	1,256	----
	Percentage of eyed egg mortality	1.4	2.4	2.4	2.1	10.7	11.4	1.1
	Accumulative percentage of mortality	11.7	14.0	12.6	17.3	30.1	28.8	12.5
Fry---------	Number of fry	1,407	3,032	20,047	29,515	26,513	9,761	----
	Fry mortality	6	12	212	405	997	361	----
	Percentage of fry mortality	0.4	0.6	1.1	1.4	3.8	3.7	0.5
	Accumulative percentage of mortality	12.1	14.3	13.5	18.4	32.7	31.4	13.0
Fingerling--	Number of fingerlings	1,401	3,020	19,835	29,110	25,516	9,400	----
	Fingerling mortality	136	63	137	400	705	264	----
	Percentage of fingerling mortality	9.7	3.1	0.7	1.4	2.8	2.8	0.8
	Accumulative percentage of mortality	20.6	16.1	14.1	19.6	34.6	33.3	13.8

[1]/ High initial loss due to transportation complication (see text).

packed by the "dry" method, was transported 55 miles by truck to the airport. The flight was first scheduled for Redding, California, but was routed through San Francisco because of inclement weather. At the airport in San Francisco, the unopened container was put in a cool room (40° F.) for 8 hours. The next morning the container was delivered by plane to Redding and from there was taken by truck to the Coleman hatchery (a distance of 14 miles). Then the eggs were poured into baskets placed in troughs. Total elapsed time from spawning to hatchery basket was 24 hours 15 minutes, a period during which the eggs were not handled except as necessary for transporting. The temperature of the water was 53° at spawning, 49° within the container at time of opening, and 54° F. at Coleman. Everything considered, the losses among the green eggs were remarkably low; and most of these losses were observed during the first week at Coleman.

The losses during the eyed-egg stage at Coleman--10.7 percent for treated eggs, 11.4 percent for the untreated--could be attributed to shock during transport rather than to the treatment. This assumption seems valid because lot 2 sustained losses comparable to those observed in lot 1 and the production group. Losses in the fry and fingerling stages of lot 3 were comparable to those observed in all other lots.

All three lots were used in the main disease study after their initial roles had been fulfilled. The results from these lots compared favorably with results from lots taken directly from production fish that had not been treated with merthiolate.

These data indicate that treating green, water-hardened chinook salmon eggs with a 1:5,000 solution of merthiolate did not adversely affect the eggs. This is not intended to imply that disinfecting necessarily inhibited any disease agents, as such a hypothesis was not tested, and there were no observations that would justify such a conclusion. The only valid conclusion is that the treatment. in itself, does not appear harmful to the green eggs.

The "dry" method of transporting green eggs appeared to be safe and efficient. This opinion is based on observation and on conversation with other investigators. It should be noted that even under very adverse conditions of transportation--long periods out of water without any effort made to improve condition; temperature differentials of spawning, transporting, and final hatchery water--the eggs carried well and suffered unexpectedly low losses, and the subsequent fish compared well in losses and in successful utilization in other work. If the necessary safeguards are taken in transportation, the "dry" method is the preferred method because of economy, facility, and relative safety.

Summary

1. Three lots of green, water-hardened chinook salmon eggs were treated with a 1:5,000 solution of merthiolate.

2. None of the lots suffered unusual or unexplainable losses that could be attributed to the treatment with merthiolate.

3. Lot 3 suffered high initial losses in the green-egg stage and lesser losses in the eyed-egg stage, all of which could be attributed to shock suffered in transport.

4. The disinfecting of green chinook salmon eggs with merthiolate is apparently safe, but no claim is made for its prophylactic efficacy because this condition was not tested in the present study.

Acknowledgments

The author wishes to express appreciation to Mr. Harlan E. Johnson, fishery management biologist, Little White Salmon National Fish Hatchery, and Mr. Everett Whealdon, Coleman National Fish Hatchery, for their cooperation and suggestions throughout the experimental period.

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MODIFICATIONS FOR THE JAR CULTURE OF TROUT EGGS

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THE JAR CULTURE OF TROUT EGGS has eliminated much of the labor and saved much of the space formerly required by the tray method of incubation. Recent modifications of the jar-culture method (Buss 1959) at the Pennsylvania State hatcheries and the Benner Spring Fish Research Station have made this method more effective and efficient. A description of these changes follows.

The major improvement has been to change the water supply from an open system (Buss 1959) to a closed system (see figure 1) using a 2-inch galvanized pipe for the inlet water supply. The advantage of the closed system is that all the jars can be treated with fungicide at one time with complete mixing, or if only a part of the jars are being used, they can be treated separately. When the unit has only a partial complement of eggs, jars at the outlet end are filled first and the treatment is made from the standpipe behind the jars containing the eggs. However, care should be taken so that treatment is made far enough behind the last jar to obtain complete mixing of the fungicide.

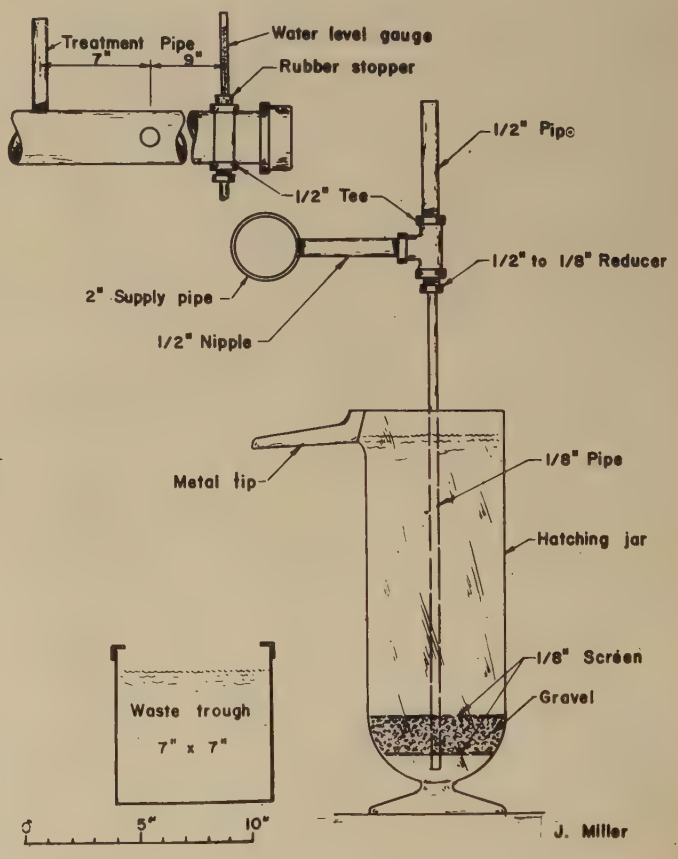

FIGURE 1.--Details of closed water system for jar incubation of trout eggs.

The fungicide found to be best suited for the jar culture of eggs is the formaldehyde treatment described by Reddecliff.[1/] This treatment consists of a 15-minute constant flow of a 1:600 concentration of formaldehyde. Two advantages of formaldehyde are that it is cheap (about 30 cents a day for a 32-jar battery), and that it is not toxic to eggs or fry at the recommended concentration.

To test the circulation of the formaldehyde solution, a stock solution of a uranin

[1/] Reddecliff, J. Formalin as a fungicide in the jar method of egg incubation. Penna. Fish Comm. 3 pp. 1958. (Mimeo.)

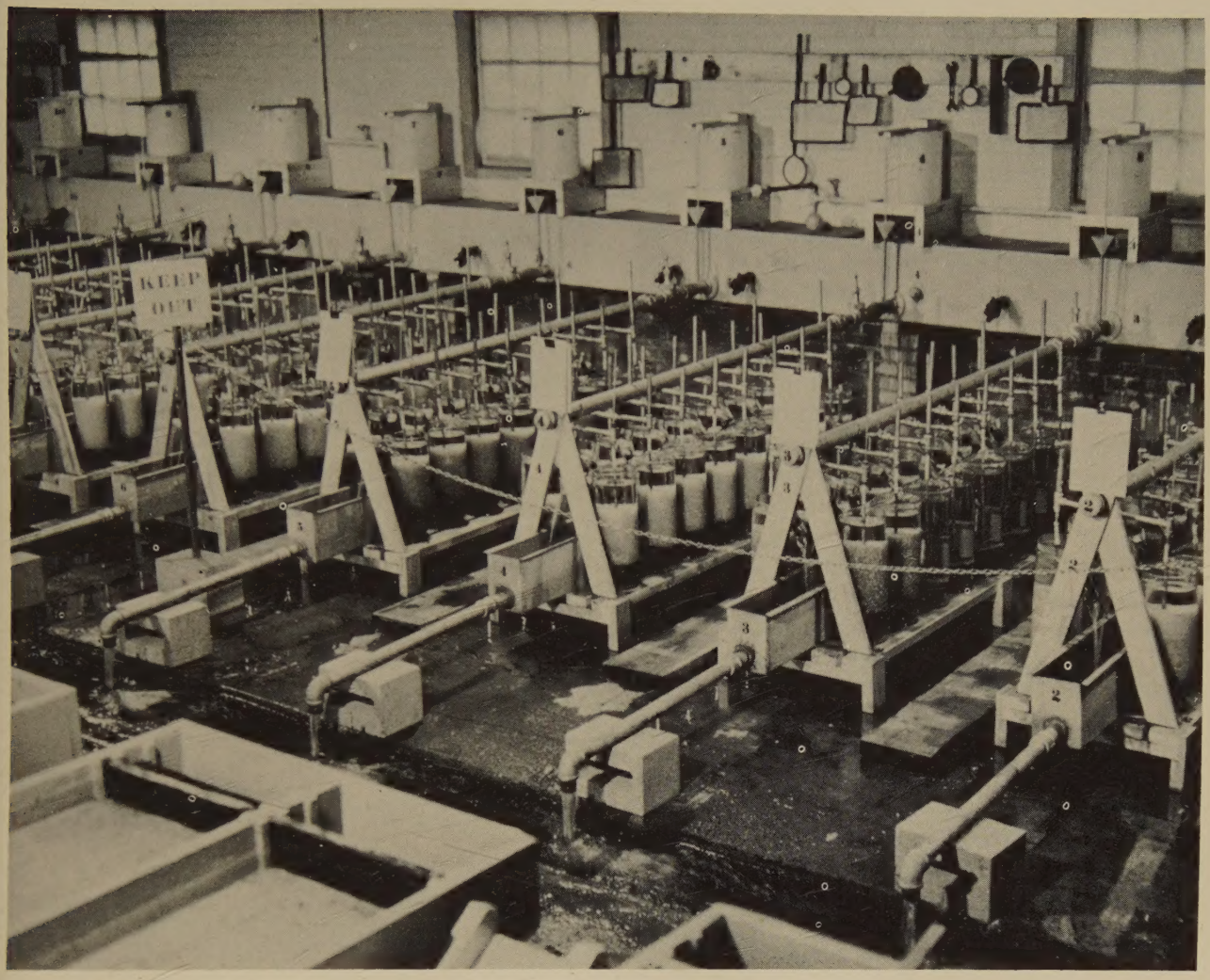

FIGURE 2.--Jar incubation of trout at the Bellefonte hatchery. Each 16-jar unit contains 64 quarts of eggs. Note constant-flow siphons in background.

dye (1 heaping teaspoon to a quart of water) is prepared. Twenty cubic centimeters of the stock solution is added to the treatment reservoir with each application of the fungicide. Effectiveness of the treatment can be observed by noting the circulation of the dye.

The time needed for measuring the flow through the units has been reduced by installing a transparent plastic tube on one of the T's above the jars (figure 1). When the flow through the unit is calculated, a mark is made on the plastic tube at the top of the water line. In succeeding treatments, if the water remains at this line, no change in water flow has occurred and no new determination of the flow is needed.

Use of 1/8-inch galvanized piping as the inlet tube for the jar supplies approximately the correct amount of water per jar. The elimination of the clamp reduces the chances of the inflow's being blocked by foreign material. If a reduced flow of water is desired, the pipe can be nippled at the bottom with a short piece of soft rubber hose.

The gravel at the bottom of the jar aids in dispersion of the water and prevents movement of the eggs. By placing

a screen above the bottom of the jar to hold the gravel, the danger of the inlet pipe's being blocked by small stones is eliminated. The screen on top of the small stones prevents the eggs from falling into the gravel.

If it is necessary to ship eyed eggs incubated in the jars, a good portion of the white eggs can be removed in a salt bath. The eggs are placed in a single layer in a box with a screen bottom. The box is then immersed slowly in a tub containing a solution of one part salt to nine parts water by weight (O'Malley 1920). If the concentration is prepared correctly, the white eggs will float and live eggs will gradually sink. The dead eggs can then be dipped off with a net the width of the box. Differences in the purity of the salt and the water quality often make it necessary to manipulate the concentration so that the desired results are obtained. Brook and brown trout eggs responded better to this flotation method than did the rainbow trout eggs. It is more difficult to precipitate the globulin in blank rainbow eggs, and therefore it is more difficult to make these eggs separate from the live eggs. Many of these eggs have to be dipped more than once. After each dipping and before the next immersion, eggs should be placed in fresh water for about one-half hour to respond best to this method.

Ten units of 16 jars each (figure 2) incubated approximately 6,500,000 eggs at the Bellefonte hatchery. Treating the closed-system units with the constant-flow siphon required 1.5 to 2 man-hours daily. This can be compared to 48 man-hours a day required when the eggs had to be hand-picked.

No disease or other adverse effects have been observed at the five Pennsylvania State trout hatcheries where these units have been installed. A wide range of water quality is found among these hatcheries.

Acknowledgments

The authors wish to thank the staff at the Bellefonte hatchery and the Benner Spring Fish Research Station for their aid and suggestions.

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Reprints of the paper may be secured from Dr. Dwight A. Webster, professor of fishery biology, Department of Conservation, Fernow Hall, Cornell University, Ithaca, New York.

Phosphorus is the mineral most frequently deficient in animals.

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